

Subpart F—Emission Regulations for 1978 and Later New Motorcycles; Test Procedures

SOURCE: 42 FR 1137, Jan. 5, 1977, unless otherwise noted.

§86.501-78 Applicability.

(a) This subpart contains the motor-cycle test procedures specified in subpart E.

(b) Provisions of this subpart apply to tests performed by both the Administrator and motor vehicle manufacturers.

§86.502-78 Definitions.

(a) The definitions in §86.402-78 apply to this subpart.

(b) [Reserved]

§86.503-78 Abbreviations.

(a) The abbreviations in §86.403-78 apply to this subpart.

(b) [Reserved]

§86.504-78 Section numbering.

(a) The section numbering system described in §86.404-78 is used in this subpart.

(b) [Reserved]

§86.505-78 Introduction; structure of subpart.

(a) This subpart describes the equipment required and the procedures to follow in order to perform exhaust emission tests on motorcycles. Subpart E sets forth the testing requirements and test intervals necessary to comply with EPA certification procedures.

(b) Three topics are addressed in this subpart. Sections 86.508 through 86.515 set forth specifications and equipment requirements; §§86.516 through 86.526 discuss calibration methods and frequency; test procedures and data requirements are listed (in approximate order of performance) in §§86.527 through 86.544.

§86.508-78 Dynamometer.

(a) The dynamometer shall have a single roll with a diameter of at least 0.400 metre.

(b) The dynamometer shall be equipped with a roll revolution counter for measuring actual distance traveled.

(c) Flywheels or other means shall be used to stimulate the inertia specified in §86.529.

(d) A variable speed cooling blower shall direct air to the vehicle. The blower outlet shall be at least 0.40 m² (4.31 ft²) and shall be squarely positioned between 0.3 m (0.98 ft) and 0.45 m (1.48 ft) in front of the vehicle's front wheel. The velocity of the air at the blower outlet shall be within the following limits (as a function of roll speed):

Actual roll speed	Allowable cooling air speed
0 km/h to 5 km/h	0 km/h to 10 km/h.
5 km/h to 10 km/h	0 km/h to roll speed + 5 km/h.
10 km/h to 50 km/h	Roll speed \pm 5 km/h.
50 km/h to 70 km/h	Roll speed \pm 10 pct.
Above 70 km/h	At least 63 km/h.

(e) The dynamometer shall comply with the tolerances in §86.529.

[42 FR 1137, Jan. 5, 1977, as amended at 42 FR 56738, Oct. 28, 1977]

§86.509-90 Exhaust gas sampling system.

(a)(1) *General.* The exhaust gas sampling system is designed to measure the true mass emissions of vehicle exhaust. In the CVS concept of measuring mass emissions, two conditions must be satisfied: the total volume of the mixture of exhaust and dilution air must be measured and a continuously proportioned volume of sample must be collected for analysis. Mass emissions are determined from the sample concentration and totalized flow over the test period.

(2) *Vehicle tailpipe to CVS duct.* For methanol fueled vehicles, cooling of the exhaust gases in the duct connecting the vehicle tailpipe to the CVS shall be minimized. This may be accomplished by:

(i) Using a duct of unrestricted length maintained at a temperature above the maximum dew point of the exhaust, but below 121 °C (250 °F); heating and possibly cooling capabilities are required; or

(ii) Using a short duct (up to 12 feet long) constructed of smooth wall pipe with a minimum of flexible sections, maintained at a temperature above the maximum dew point of the exhaust, but below 121 °C (250 °F), prior to the test and during any breaks in the test

and uninsulated during the test (insulation may remain in place and/or heating may occur during testing provided maximum temperature is not exceeded); or

(iii) Using smooth wall duct less than five feet long with no required heating. A maximum of two short flexible connectors are allowed under this option; or

(iv) Omitting the duct and performing the exhaust gas dilution function at the motorcycle tailpipe exit.

(3) *Positive displacement pump.* The Positive Displacement Pump-Constant Volume Sampler (PDP-CVS), Figure F90-1 satisfies the first condition by metering at a constant temperature and pressure through the pump. The

total volume is measured by counting the revolutions made by the calibrated positive displacement pump. The proportional samples are achieved by sampling at a constant flow rate. For methanol-fueled motorcycle sample lines for the methanol and formaldehyde samples are heated to prevent condensation. The temperature of the sample lines shall be more than 3 °C (5 °F) above the maximum dew point of the sample, but below 121 °C (250 °F). (Note: For 1990 through 1994 model year methanol-fueled motorcycles, methanol and formaldehyde sampling may be omitted provided the bag sample (hydrocarbons and methanol) is analyzed using a HFID calibrated with methanol.)

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(4) *Critical flow venturi.* The operation of the Critical Flow Venturi—Constant Volume Sampler (CFV-CVS) sample system, Figure F90-2, is based upon the principles of fluid dynamics associated with critical flow. Proportional sampling throughout temperature excursions is maintained by use of small

CFVs in the sample lines, which respond to the varying temperatures in the same manner as the main CFV. For methanol-fueled motorcycles, the methanol and formaldehyde sample lines are heated to prevent condensation. The temperature of the sample lines shall be more than 3 °C (5 °F) above the maximum dew point of the sample, but below 121 °C (250 °F). Care must be taken to ensure that the CFVs of the sample probes are not heated since heating of the CFVs would cause

loss of proportionality. (Note: For 1990 through 1994 model year methanol-fueled motorcycles, methanol and formaldehyde sampling may be omitted provided the bag sample (hydrocarbons and methanol) is analyzed using a HFID calibrated with methanol.) Total flow per test is determined by continuously computing and integrating instantaneous flow. A low response time temperature sensor is necessary for accurate flow calculation.

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(5) *Electronic Flow Control.* The Critical Flow Venturi—Electronic Flow Control—Constant Volume Sampler (CFV-EFC-CVS) system is identical to the CFV-CVS system described in paragraphs (a)(4) and (c) of this section, except that it maintains proportional sampling for methanol and formaldehyde by measuring the CVS flow rate,

and electronically controlling sample flow rates. It is recommended that sample volumes be measured by separate flow meters. For methanol-fueled motorcycles, the sample lines for the methanol and formaldehyde samples are heated to prevent condensation. The temperature of the sample lines shall be more than 20 °F (11 °C) above

the maximum dew point of the sample, but below 121 °C (250 °F).

(6) *Other systems.* Other sampling systems may be used if shown to yield equivalent results, and if approved in advance by the Administrator (e.g., a heat exchanger with the CFV-CVS or an electronic flow integrator without a heat exchanger, with the PDP-CVS).

(b) *Component description, PDP-CVS.* The PDP-CVS, Figure F90-1, consists of a dilution air filter and mixing assembly, heat exchanger, positive displacement pump, sampling systems including, probes and sampling lines which, in the case of the methanol-fueled motorcycles, are heated to prevent condensation (heating of the sample lines may be omitted, provided the methanol and formaldehyde sample collection systems are close coupled to the probes thereby preventing loss of sample due to cooling and resulting condensation in the sample lines), and associated valves, pressure and temperature sensors. The PDP-CVS shall conform to the following requirements:

(1) Static pressure variations at the tailpipe(s) of the vehicle shall remain within ± 1.25 kPa (± 5.02 in H₂O) of the static pressure variations measured during a dynamometer driving cycle with no connection to the tailpipe(s). (Sampling systems capable of maintaining the static pressure to within ± 0.25 kPa (± 1.00 in. H₂O) will be used by the Administrator if a written request substantiates the need for this closer tolerance.)

(2) The gas mixture temperature, measured at a point immediately ahead of the positive displacement pump, shall be within ± 5 °C (9 °F) of the designed operating temperature at the start of the test. The gas mixture temperature variation from its value at the start of the test shall be limited to ± 5 °C (9 °F) during the entire test. The temperature measuring system shall have an accuracy and precision of ± 1 °C (1.8 °F).

(3) The pressure gauges shall have an accuracy and precision of ± 0.4 kPa (± 3 mm Hg).

(4) The location of the dilution air inlet shall be placed so as to use test-cell air for dilution and the flow capacity of the CVS shall be large enough to completely eliminate water condensa-

tion in the dilution and sampling systems. Control of water condensation with methanol-fueled vehicles is critical. Additional care may also be required to eliminate water condensation when testing natural gas and liquefied petroleum gas-fueled vehicles. (Procedures for determining CVS flow rates are detailed in "Calculation of Emissions and Fuel Economy When Using Alternative Fuels," EPA 460/3-83-009.) Dehumidifying the dilution air before entering the CVS is allowed. Heating the dilution air is also allowed, provided:

(i) The air (or air plus exhaust gas) temperature does not exceed 121 °C (250 °F).

(ii) Calculation of the CVS flow rate necessary to prevent water condensation is based on the lowest temperature encountered in the CVS prior to sampling. (It is recommended that the CVS system be insulated when heated dilution air is used.)

(iii) The dilution ratio is sufficiently high to prevent condensation in bag samples as they cool to room temperature.

(5) Sample collection bags for dilution air and exhaust samples (hydrocarbons and carbon monoxide) shall be of sufficient size so as not to impede sample flow. A single dilution air sample, covering the total test period, may be collected for the determination of methanol and formaldehyde background (methanol-fueled motorcycles).

(6) The methanol sample collection system and the formaldehyde sample collection system shall each be of sufficient capacity so as to collect samples of adequate size for analysis without significant impact on the volume of dilute exhaust passing through the PDP. The systems shall also comply with the following requirements that apply to the design of the systems, not to individual tests:

(i) The methanol system shall be designed such that if a test motorcycle continuously emitted the maximum allowable level of methanol (based on all applicable standards) the measured concentration in the primary impinger would exceed either 25 mg/l or a concentration equal to 25 times the limit of detection for the GC analyzer.

(ii) The formaldehyde system shall be designed such that if a test motorcycle continuously emitted formaldehyde at a rate equal to twenty percent of the maximum allowable level of THCE (*i.e.*, 1.0 g/km for a 5.0 g/km standard), or the maximum formaldehyde level allowed by a specific formaldehyde standard, whichever is less, the concentration of formaldehyde in the DNPH solution of the primary impinger, or solution resulting from the extraction of the DNPH cartridge, shall exceed either 2.5 mg/l or a concentration equal to 25 times the limit of detection for the HPLC analyzer.

(iii) The methanol and formaldehyde systems shall be designed such that the primary impinger collects at least 90 percent of the analyte in the samples. The remaining analyte shall be collected by the secondary impinger. This requirement does not apply to dilution air samples, since they do not require secondary impingers, or to samples in which the concentrations approach the limit of detection.

(c) *Component description, CFV-CVS.* The CFV-CVS sample system, Figure F90-2, consists of a dilution air filter and mixing assembly, a cyclone particulate separator, unheated sampling venturies for the bag samples, and for the methanol and formaldehyde samples from methanol-fueled vehicles, samples lines heated to prevent condensation for the methanol and formaldehyde samples from methanol fueled vehicles (heating of the sample lines may be omitted provided, the methanol and formaldehyde sample collection systems are close coupled to the probes thereby preventing loss of sample due to cooling and resulting condensation in the sample lines), a critical flow venturi, and assorted valves, and pressure and temperature sensors. The CFV sample system shall conform to the following requirements:

(1) Static pressure variations at the tailpipe(s) of the vehicle shall remain within ± 1.25 kPa (5.02 in H₂O) of the static pressure variations measured during a dynamometer driving cycle with no connection to the tailpipe(s). (Sampling systems capable of maintaining the static pressure to within ± 0.25 kPa (1.00 in H₂O) will be used by the Administrator if a written request

substantiates the need for this closer tolerance.)

(2) The temperature measuring system shall have an accuracy and precision of ± 1 °C (1.8 °F) and a response time of 0.100 second to 62.5 percent of a temperature change (as measured in hot silicone oil).

(3) The pressure measuring system shall have an accuracy and precision of ± 0.4 kPa (± 3 mm Hg).

(4) The location of the dilution air inlet shall be placed so as to use test-cell air for dilution and the flow capacity of the CVS shall be large enough to completely eliminate water condensation in the dilution and sampling systems. Control of water condensation with methanol-fueled vehicles is critical. Additional care may also be required to eliminate water condensation when testing natural gas and liquefied petroleum gas-fueled vehicles. (Procedures for determining CVS flow rates are detailed in "Calculation of Emissions and Fuel Economy When Using Alternative Fuels," EPA 460/3-83-009.) Dehumidifying the dilution air before entering the CVS is allowed. Heating the dilution air is also allowed, provided:

(i) The air (or air plus exhaust gas) temperature does not exceed 250 °F.

(ii) Calculation of the CVS flow rate necessary to prevent water condensation is based on the lowest temperature encountered in the CVS prior to sampling. (It is recommended that the CVS system be insulated when heated dilution air is used.)

(iii) The dilution ratio is sufficiently high to prevent condensation in bag samples as they cool to room temperature.

(5) Sample collection bags for dilution air and exhaust samples (hydrocarbons and carbon monoxide) shall be of sufficient size so as not to impede sample flow. A single dilution air sample, covering the total test period, may be collected for the determination of methanol and formaldehyde background (methanol-fueled motorcycles).

(6) The methanol sample collection system and the formaldehyde sample collection system shall each be of sufficient capacity so as to collect samples of adequate size for analysis without

significant impact on the volume of dilute exhaust passing through the CVS. The systems shall also comply with the following requirements that apply to the design of the systems, not to individual tests:

(i) The methanol system shall be designed such that if a test motorcycle continuously emitted the maximum allowable level of methanol (based on all applicable standards) the measured concentration in the primary impinger would exceed either 25 mg/l or a concentration equal to 25 times the limit of detection for the GC analyzer.

(ii) The formaldehyde system shall be designed such that if a test motorcycle continuously emitted formaldehyde at a rate equal to twenty percent of the maximum allowable level of THCE (*i.e.*, 1.0 g/km for a 5.0 g/km standard), or the maximum formaldehyde level allowed by a specific formaldehyde standard, whichever is less, the concentration of formaldehyde in the DNPH solution of the primary impinger, or solution resulting from the extraction of the DNPH cartridge, shall exceed either 2.5 mg/l or a concentration equal to 25 times the limit of detection for the HPLC analyzer.

(iii) The methanol and formaldehyde systems shall be designed such that the primary impinger collects at least 90 percent of the analyte in the samples. The remaining analyte shall be collected by the secondary impinger. This requirement does not apply to dilution air samples, since they do not require secondary impingers, or to samples in which the concentrations approach the limit of detection.

(d) *Component description, CFV-EFC- CVS.* The CVS sample system is identical to the system described in paragraph (c) of this section, plus includes a means of electronically measuring the CVS flow rate, and electronic mass

flow controllers for the methanol and formaldehyde sample lines, and separate flow meters to totalize sample flow volumes (optional). The EFC sample system shall conform to all of the requirements listed in paragraph (c) of this section, except that the methanol and formaldehyde samples may both be drawn from a single static probe. It also must comply with the following additional requirements:

(1) The ratio of the CVS flow rate to the sample flow rate shall not deviate from the ratio at the start of the test by more than ± 5 percent. (The volumetric sample flow rate shall be varied inversely with the square root of the bulk stream temperature.)

(2) Flow totalizers for methanol and/or formaldehyde samples shall have an accuracy of ± 2 percent. Total sample volumes may be obtained from the flow controllers, with the advance approval of the administrator, provided that the controllers can be shown to have an accuracy of ± 2 percent.

[54 FR 14539, Apr. 11, 1989, as amended at 59 FR 48512, Sept. 21, 1994; 60 FR 34351, June 30, 1995]

§ 86.511-90 Exhaust gas analytical system.

(a) *Schematic drawings.* Figure F90-3 is a schematic drawing of the exhaust gas analytical system for analysis of hydrocarbons (HC) (hydrocarbons plus methanol in the case of methanol-fueled motorcycles), carbon monoxide (CO), carbon dioxide (CO₂), and oxides of nitrogen (NO_x). Since various configurations can produce accurate results, exact conformance with the drawing is not required. Additional components such as instruments, valves, solenoids, pumps and switches may be used to provide additional information and coordinate the functions of the component systems

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(b) *Major component description.* The exhaust gas analytical system for HC, CO and CO₂, Figure F90-3, consists of a flame ionization detector (FID) (heated (235°±15 °C (113°±8 °C)) for methanol-fueled vehicles) for the determination of hydrocarbons, nondispersive infrared analyzers (NDIR) for the determination of carbon monoxide and carbon dioxide

and, if oxides of nitrogen are measured, a chemiluminescence analyzer (CL) for the determination of oxides of nitrogen. The analytical system for methanol consists of a gas chromatograph (GC) equipped with a flame ionization detector. The analysis for formaldehyde is performed using high pressure liquid chromatography (HPLC) of 2,4-

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dinitrophenylhydrazine (DNPH) derivatives using ultraviolet (UV) detection. The exhaust gas analytical system shall conform to the following requirements:

(1) The CL requires that the nitrogen dioxide present in the sample be converted to nitric oxide before analysis. Other types of analyzers may be used if shown to yield equivalent results and if approved in advance by the Administrator.

(2) The carbon monoxide (CO) NDIR analyzer may require a sample conditioning column containing CaSO₄, or indicating silica gel to remove water vapor and containing ascarite to remove carbon dioxide from the CO analysis stream.

(i) If CO instruments which are essentially free of CO₂ and water vapor interference are used, the use of the conditioning column may be deleted, see §§ 86.522 and 86.544.

(ii) A CO instrument will be considered to be essentially free of CO₂ and water vapor interference if its response to a mixture of 3 percent CO₂ in N₂

which has been bubbled through water at room temperature produces an equivalent CO response, as measured on the most sensitive CO range, which is less than 1 percent of full scale CO concentration on ranges above 300 ppm full scale or less than 3 ppm on ranges below 300 ppm full scale; see § 86.522.

(c) *Other analyzers and equipment.* Other types of analyzers and equipment may be used if shown to yield equivalent results and if approved in advance by the Administrator.

[54 FR 14544, Apr. 11, 1989]

§ 86.513-87 Fuel and engine lubricant specifications.

(a) Gasoline having the following specifications will be used by the Administrator in exhaust emission testing. Gasoline having the following specifications or substantially equivalent specifications approved by the Administrator, shall be used by the manufacturer for emission testing except that the lead and octane specifications do not apply.

Item designation	ASTM	Leaded	Unleaded
Octane, research, min	D2699	100	93
Pb (organic), g/liter (g/U.S. gal.)	D3237	¹ 0.026 (0.100 max)	¹ 0.013 (0.050 max)
Distillation Range:	D86.		
IBP, °C (°F)		23.9-35 (75-95)	23.9-35 (75-95)
10 pct. point, °C (°F)		48.9-57.2 (120-135)	48.9-57.2 (120-135)
50 pct. point, °C (°F)		93.3-110 (200-230)	93.3-110 (200-230)
90 pct. point, °C (°F)		148.9-162.8 (300-325)	148.9-162.8 (300-325)
EP, °C (°F)		212.8(415)	212.8(415)
Sulfur, wt. pct., max	D1266	0.10	0.10
Phosphorus, g/liter (g/U.S. gal.), max		0.0026 (0.01)	0.0013 (0.005)
RVP, KPa (psi)	D323	55.2-63.4 (8.0-9.2)	55.2-63.4 (8.0-9.2)
Hydrocarbon composition:			
Olefins, pct., max	D1319	10	10
Aromatics, pct., max		35	35
Saturates		(²)	(²)

¹ Maximum.

² Remainder.

(b)(1) Gasoline and engine lubricants representative of commercial fuels and engine lubricants which will be generally available through retail outlets shall be used in service accumulation.

(2) For leaded fuel the lead content shall not exceed 0.100 gram lead per gallon leaded gasoline.

(3) Where the Administrator determines that vehicles represented by a test vehicle will be operated using gasoline of different lead content than that prescribed in this paragraph, he may consent in writing to use a gasoline with a different lead content.

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(4) The octane rating of the gasoline used shall be no higher than 4.0 research octane numbers above the minimum recommended by the manufacturer.

(5) The Reid Vapor Pressure of the fuel used shall be characteristic of the motor fuel during the season in which the service accumulation takes place.

(6) If the manufacturer specifies several lubricants to be used by the ultimate purchaser, the Administrator will select one to be used during service accumulation.

(c) The specification range of the fuels and engine lubricants to be used under paragraph (b) of this section shall be reported in accordance with § 86.416.

(d) The same lubricant(s) shall be used for both service accumulation and emission testing.

(e) Fuels not meeting the specifications set forth in this section may be used only with the advance approval of the Administrator.

[51 FR 24611, July 7, 1986, as amended at 52 FR 47869, Dec. 16, 1987]

§ 86.513–90 Fuel and engine lubricant specifications.

(a) Gasoline having the following specifications will be used by the Administrator in exhaust emission testing. Gasoline having the following specifications or substantially equivalent specifications approved by the Administrator, shall be used by the manufacturer for emission testing except that the octane specifications do not apply.

Item	ASTM	Value
Octane, research, minimum	D2699	96
Lead (organic):		
g/liter	D3237	¹ 0.013
(g/U.S. gal.)		¹ (0.050)
Distillation range:		
IBP:		
°C	D86	23.9–35
(°F)		(75–95)
10 pct. point:		
°C	D86	48.9–57.2
(°F)		(120–135)
50 pct. point:		
°C	D86	93.3–110
(°F)		(200–230)
90 pct. point:		
°C	D86	148.9–
(°F)		162.8
EP:		(300–325)
°C max	D86	212.8

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Item	ASTM	Value
(°F)		(415)
Sulfur, weight percent, maximum	D1266	0.10
Phosphorus:		
g/liter, max	D3231	0.0013
(g/U.S. gal)		(0.005)
RVP, kPa (psi)	D323	55.2–63.4
		(8.0–9.2)
Hydrocarbon composition:		
Olefins, percent, maximum	D1319	10
Aromatics, percent, maximum	D1319	35
Saturates	D1319	Remainder

¹ Maximum.

(b)(1) Unleaded gasoline and engine lubricants representative of commercial fuels and engine lubricants which will be generally available through retail outlets shall be used in service accumulation.

(2) The octane rating of the gasoline used shall be no higher than 4.0 Research octane numbers above the minimum recommended by the manufacturer.

(3) The Reid Vapor Pressure of the fuel used shall be characteristic of the motor fuel during the season in which the service accumulation takes place.

(4) If the manufacturer specifies several lubricants to be used by the ultimate purchaser, the Administrator will select one to be used during service accumulation.

(c) Methanol fuel used for exhaust and evaporative emission testing and in service accumulation of methanol-fueled motorcycle vehicles shall be representative of commercially available methanol fuel and shall consist of at least 50 percent methanol by volume.

(1) Manufacturers shall recommend the methanol fuel to be used for testing and service accumulation in accordance with paragraph (c).

(2) The Administrator shall determine the methanol fuel to be used for testing and service accumulation.

(d) Other methanol fuels may be used for testing and service accumulation provided:

(1) They are commercially available, and

(2) Information, acceptable to the Administrator, is provided to show that only the designated fuel would be used in customer service, and

(3) Use of a fuel listed under paragraph (a)(3) of this section would have a detrimental effect on emissions or durability, and

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(4) Written approval from the Administrator of the fuel specifications must be provided prior to the start of testing.

(e) The specification range of the fuels and engine lubricants to be used under paragraph (b) of this section shall be reported in accordance with § 86.416.

(f) The same lubricant(s) shall be used for both service accumulation and emission testing.

(g) Fuels not meeting the specifications set forth in this section may be used only with the advance approval of the Administrator.

(h) *Mixtures of petroleum and methanol fuels for flexible fuel motorcycles.* (1) Mixtures of petroleum and methanol fuels used for exhaust and evaporative emission testing and service accumulation for flexible fuel motorcycles shall be within the range of fuel mixtures for which the vehicle was designed.

(2) Manufacturer testing and service accumulation may be performed using only those mixtures (mixtures may be different for exhaust testing, evaporative testing, and service accumulation) expected to result in the highest emissions, provided:

(i) The fuels which constitute the mixture will be used in customer service, and

(ii) Information, acceptable to the Administrator, is provided by the manufacturer to show that the designated fuel mixtures would result in the highest emissions, and

(iii) Written approval from the Administrator of the fuel specifications must be provided prior to the start of testing.

(3) The specification range of the fuels to be used under paragraph (h)(1) of this section shall be reported in accordance with § 86.090 21(b)(3).

[53 FR 476, Jan. 7, 1988, as amended at 54 FR 14546, Apr. 11, 1989]

§ 86.513-94 Fuel and engine lubricant specifications.

(a) *Gasoline.* (1) Gasoline having the following specifications will be used by the Administrator in exhaust emission testing of gasoline-fueled motorcycles. Gasoline having the following specifications or substantially equivalent specifications approved by the Admin-

istrator, shall be used by the manufacturer for emission testing except that the octane specifications do not apply.

Item	ASTM	Value
Octane, research, minimum	D2699	96
Lead (organic): g/liter (g/U.S. gal.)	D3237	¹ 0.013 ¹ (0.050)
Distillation range: IBP: °C (°F)	D86	23.9-35 (75-95)
10 pct. point: °C (°F)	D86	48.9-57.2 (120-135)
50 pct. point: °C (°F)	D86	93.3-110 (200-230)
90 pct. point: °C (°F)	D86	148.9- 162.8 (300-325)
EP: max. °C (°F)	D86	212.8 (415)
Sulfur, max. wt. %	D1266	0.10
Phosphorus: max. g/liter (g/U.S. gal.)	D3231	0.0013 (0.005)
RVP kPa (psi)	D323	55.2-63.4 (8.0-9.2)
Hydrocarbon composition:		
Olefins, max., %	D1319	10
Aromatics, max., %	D1319	35
Saturates	D1319	Remainder

¹ Maximum.

(2) Unleaded gasoline and engine lubricants representative of commercial fuels and engine lubricants which will be generally available through retail outlets shall be used in service accumulation.

(3) The octane rating of the gasoline used shall be no higher than 4.0 Research octane numbers above the minimum recommended by the manufacturer.

(4) The Reid Vapor Pressure of the gasoline used shall be characteristic of commercial gasoline fuel during the season in which the service accumulation takes place.

(b) *Methanol fuel.* (1) Methanol fuel used for exhaust and evaporative emission testing and in service accumulation of methanol-fueled motorcycles shall be representative of commercially available methanol fuel and shall consist of at least 50 percent methanol by volume.

(2) Manufacturers shall recommend the methanol fuel to be used for testing and service accumulation in accordance with paragraph (b)(1) of this section.

(3) The Administrator shall determine the methanol fuel to be used for testing and service accumulation.

(4) Other methanol fuels may be used for testing and service accumulation provided:

(i) They are commercially available; and

(ii) Information, acceptable to the Administrator, is provided to show that only the designated fuel would be used in customer service; and

(iii) Use of a fuel listed under paragraphs (b)(1), (b)(2) or (b)(3) of this section would have a detrimental effect on emissions or durability; and

(iv) Written approval from the Administrator of the fuel specifications must be provided prior to the start of testing.

(c) *Mixtures of petroleum and methanol fuels for flexible fuel motorcycles.* (1) Mixtures of petroleum and methanol fuels used for exhaust and evaporative emission testing and service accumulation for flexible fuel motorcycles shall consist of the petroleum fuel listed in paragraph (a) of this section and the methanol fuel listed in paragraph (b), and shall be within the range of fuel mixtures for which the vehicle was designed, as reported in accordance with § 86.90–21. The Administrator may use any fuel or fuel mixture within this range for testing.

(2) The fuel mixtures used by the manufacturers shall be sufficient to demonstrate compliance over the full design range, and shall include:

(i) For emission testing,

(A) The petroleum fuel specified in paragraph (a) or (b),

(B) A methanol fuel representative of the methanol fuel expected to the found in use, as specified in paragraph (b),

(ii) For service accumulation, an alternating combination of the fuels specified in paragraphs (a) and (b) will be used to demonstrate the durability of the emission control systems based on good engineering judgement. The combination shall be selected such that the cumulative volumes of both the methanol fuel and the petroleum fuel used shall be at least twenty-five percent of the total fuel volume. The fuels shall be alternated at mileage intervals not to exceed 1,000 kilometers.

(3) The specification range of the fuels to be used under paragraph (c) of

this section shall be reported in accordance with § 86.094–21.

(d) *Natural gas-fuel.* (1) Natural gas-fuel having the following specifications will be used by the Administrator for exhaust and evaporative emission testing of natural gas-fueled motorcycles. Natural gas-fuel having the following specifications or substantially similar specifications approved by the Administrator, shall be used by the manufacturer for emission testing.

NATURAL GAS CERTIFICATION FUEL
SPECIFICATIONS

Item		ASTM test method No.	Value
Methane	min. mole pct.	D1945	89.0
Ethane	max. mole pct.	D1945	4.5
C ₃ and higher	max. mole pct.	D1945	2.3
C ₄ and higher	max. mole pct.	D1945	0.2
Oxygen	max. mole pct.	D1945	0.6
Inert gases: Sum of CO ₂ and N ₂	max. mole pct.	D1945	4.0
Odorant ¹			

¹ The natural gas at ambient conditions must have a distinctive odor potent enough for its presence to be detected down to a concentration in air of not over 1/5 (one-fifth) of the lower limit of flammability.

(2) Natural gas-fuel and engine lubricants representative of commercial fuels and engine lubricants which will be generally available through retail outlets shall be used in service accumulation.

(3) Other natural gas-fuels may be used for testing and service accumulation provided:

(i) They are commercially available;

(ii) Information, acceptable to the Administrator, is provided to show that only the designated fuel would be used in customer service;

(iii) Written approval from the Administrator of the fuel specifications must be provided prior to the start of testing.

(e) *Liquefied petroleum gas-fuel.* (1) Liquefied petroleum gas-fuel used for exhaust and evaporative emission testing and in service accumulation of liquefied petroleum gas-fueled motorcycles shall be commercially available liquefied petroleum gas-fuel.

(2) Manufacturers shall recommend the liquefied petroleum gas-fuel to be used for testing and service accumulation in accordance with paragraph (e)(1) of this section.

(3) The Administrator shall determine the liquefied petroleum gas-fuel to be used for testing and service accumulation.

(4) Other liquefied petroleum gas-fuels may be used for testing and service accumulation provided:

(i) They are commercially available;

(ii) Information, acceptable to the Administrator, is provided to show that only the designated fuel would be used in customer service; and

(iii) Written approval from the Administrator of the fuel specifications must be provided prior to the start of testing.

(f) *Lubricants.* (1) If the manufacturer specifies several lubricants to be used by the ultimate purchaser, the Administrator will select one to be used during service accumulation.

(2) The same lubricant(s) shall be used for both service accumulation and emission testing.

(g) The specification range of the fuels and of the engine lubricants to be used under paragraphs (a), (b), (c), (d) and (e) of this section shall be reported in accordance with § 86.416.

(h) Written approval from the Administrator of the fuel and lubricant specifications must be provided prior to the start of testing.

[59 FR 48512, Sept. 21, 1994, as amended at 60 FR 34354, June 30, 1995]

§ 86.514-78 Analytical gases.

(a) *Analyzer gases.* (1) Gases for the CO and CO₂ analyzers shall be single blends of CO and CO₂ respectively using nitrogen as the diluent.

(2) Gases for the THC analyzer shall be:

(i) Single blends of propane using air as the diluent; and

(ii) Optionally, for response factor determination, single blends of methanol using air as the diluent.

(3) Gases for the NO_x analyzer shall be single blends of NO named as NO_x with a maximum NO₂ concentration of 5 percent of the nominal value using nitrogen as the diluent.

(4) [Reserved]

(5) The allowable zero gas (air or nitrogen) impurity concentrations shall not exceed 1 ppm equivalent carbon response, 1 ppm carbon monoxide, 0.04

percent (400 ppm) carbon dioxide, and 0.1 ppm nitric oxide.

(6) "Zero grade air" includes artificial "air" consisting of a blend of nitrogen and oxygen with oxygen concentrations between 18 and 21 mole percent.

(7) The use of proportioning and precision blending devices to obtain the required analyzer gas concentrations is allowable provided their use has been approved in advance by the Administrator.

(b) Calibration gases (not including methanol) shall be known to within 2 percent of true values.

(c) Methanol in air gases used for response factor determination shall:

(1) Be traceable to within ± 2 percent of NIST (formerly NBS) gas standards, or other gas standards which have been approved by the Administrator; and

(2) Remain within ± 2 percent of the labeled concentration. Demonstration of stability shall be based on a quarterly measurement procedure with a precision of ± 2 percent (two standard deviations), or other method approved by the Administrator. The measurement procedure may incorporate multiple measurements. If the true concentration of the gas changes by more than two percent, but less than ten percent, the gas may be relabeled with the new concentration.

[42 FR 1137, Jan. 5, 1977, as amended at 60 FR 34354, June 30, 1995]

§ 86.515-78 EPA urban dynamometer driving schedule.

(a) The dynamometer driving schedules are listed in appendix I. The driving schedules are defined by a smooth trace drawn through the specified speed vs. time relationships. They consist of a nonrepetitive series of idle, acceleration, cruise, and deceleration modes of various time sequences and rates. Appropriate driving schedules are as follows:

Class I—Appendix I(c)

Class II—Appendix I(b)

Class III—Appendix I(b)

(b) The speed tolerance at any given time on the dynamometer driving schedule prescribed in appendix I or as printed on a driver's aid chart approved by the Administrator, when conducted

to meet the requirements of §86.537 is defined by upper and lower limits. The upper limit is 3.2 km/h (2 mph) higher than the highest point on the trace within 1 second of the given time. The lower limit is 3.2 km/h (2 mph) lower than the lowest point on the trace within 1 second of the given time. Speed variations greater than the tolerances (such as may occur during gear changes) are acceptable provided they occur for less than 2 seconds on any occasion. Speeds lower than those prescribed are acceptable provided the vehicle is operated at maximum available power during such occurrences. When conducted to meet the requirements of §86.532 the speed tolerance shall be as specified above, except that the upper and lower limits shall be 6.4 km/h (4 mph).

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(c) Figure F78-4 shows the range of acceptable speed tolerances for typical points. Figure F78-4(a) is typical of portions of the speed curve which are increasing or decreasing throughout the two second time interval. Figure F78-4(b) is typical of portions of the speed curve which include a maximum or minimum value.

§86.516-90 Calibrations, frequency and overview.

(a) Calibrations shall be performed as specified in §§86.517 through 86.526.

(b) [Reserved]

(c) At least monthly or after any maintenance which could alter calibration, the following calibrations and checks shall be performed:

(1) Calibrate the hydrocarbon analyzer, methane analyzer, carbon dioxide analyzer, carbon monoxide analyzer, and oxides of nitrogen analyzer (certain analyzers may require more frequent calibration depending on particular equipment and uses).

(2) Calibrate the dynamometer. If the dynamometer receives a weekly performance check (and remains within

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calibration), the monthly calibration need not be performed.

(3) Check the oxides of nitrogen converter efficiency.

(d) At least weekly or after any maintenance which could alter calibration, the following calibrations and checks shall be performed:

(1) [Reserved]

(2) Perform a CVS system verification, and

(3) Run a performance check on the dynamometer. This check may be omitted if the dynamometer has been calibrated within the preceding month.

(e) The CVS positive displacement pump or Critical Flow Venturi shall be calibrated following initial installation, major maintenance or as necessary when indicated by the CVS system verification (described in § 86.519).

(f) Sample conditioning columns, if used in the CO analyzer train, should be checked at a frequency consistent with observed column life or when the indicator of the column packing begins to show deterioration.

[54 FR 14546, Apr. 11, 1989, as amended at 58 FR 58423, Nov. 1, 1993; 60 FR 34354, June 30, 1995]

§ 86.518-78 Dynamometer calibration.

(a) The dynamometer shall be calibrated at least once each month or performance verified at least once each week and then calibrated as required. The dynamometer is driven above the test speed range. The device used to drive the dynamometer is then disengaged from the dynamometer and the roll is allowed to coast down. The kinetic energy of the system is dissipated by the dynamometer. This method neglects the variations in roll bearing friction due to the drive axle weight of the vehicle.

(b) Calibration shall consist of coasting down the dynamometer for each inertia load combination used. Coastdown times for the interval from 70 to 60 km/h shall be within the tolerances specified in § 86.529. The dynamometer adjustments necessary to produce these results shall be noted for future reference.

(c) The performance check consists of conducting a dynamometer coastdown at one or more inertia-horsepower settings and comparing the coastdown

time to the table in Figure F98-9 of § 86.529-98. If the coastdown time is outside the tolerance, a new calibration is required.

[42 FR 1137, Jan. 5, 1977, as amended at 63 FR 11849, Mar. 11, 1998]

§ 86.519-78 Constant volume sampler calibration.

The CVS (Constant Volume Sampler) is calibrated using an accurate flowmeter and restrictor valve. Measurements of various parameters are made and related to flow through the unit. Procedures used by EPA for both PDP (Positive Displacement Pump) and CFV (Critical Flow Venturi) are outlined below. Other procedures yielding equivalent results may be used if approved in advance by the Administrator. After the calibration curve has been obtained, verification of the entire system can be performed by injecting a known mass of gas into the system and comparing the mass indicated by the system to the true mass injected. An indicated error does not necessarily mean that the calibration is wrong, since other factors can influence the accuracy of the system, e.g. analyzer calibration. A verification procedure is found in paragraph (c) of this section.

(a) *PDP calibration.* (1) The following calibration procedure outlines the equipment, the test configuration, and the various parameters which must be measured to establish the flow rate of the constant volume sampler pump. All the parameters related to the pump are simultaneously measured with the parameters related to a flowmeter which is connected in series with the pump. The calculated flow rate (at pump inlet absolute pressure and temperature) can then be plotted versus a correlation function which is the value of a specific combination of pump parameters. The linear equation which relates the pump flow and the correlation function is then determined. In the event that a CVS has a multiple speed drive, a calibration for each range used must be performed.

(2) This calibration procedure is based on the measurement of the absolute values of the pump and flowmeter parameters that relate the flow rate at each point. Three conditions must be

maintained to assure the accuracy and integrity of the calibration curve. First, the pump pressures should be measured at taps on the pump rather than at the external piping on the pump inlet and outlet. Pressure taps that are mounted at the top center and bottom center of the pump drive headplate are exposed to the actual pump cavity pressures, and therefore reflect the absolute pressure differentials. Secondly, temperature stability must be maintained during the calibration. The laminar flowmeter is sensitive to inlet temperature oscillations which cause the data points to be scattered. Gradual changes (± 1 °C (1.8 °F)) in temperature are acceptable as long

as they occur over a period of several minutes. Finally, all connections between the flowmeter and the CVS pump must be absolutely void of any leakage.

(3) During an exhaust emission test the measurement of these same pump parameters enables the user to calculate the flow rate from the calibration equation.

(4) Connect a system as shown in Figure F78-5. Although particular types of equipment are shown, other configurations that yield equivalent results may be used if approved in advance by the Administrator. For the system indicated, the following data with given accuracy are required:

CALIBRATION DATA MEASUREMENTS

Parameter	Symbol	Units	Tolerances
Barometric pressure (corrected)	P _B	kPa (in. Hg)	± 0.03 kPa (± 0.01 in. Hg).
Ambient temperature	T _A	°C (°F)	± 0.3 °C (± 0.54 °F).
Air temperature into LFE	ETI	°C (°F)	± 0.15 °C (± 0.27 °F).
Pressure depression upstream of LFE	EPI	kPa (in. H ₂ O)	± 0.01 kPa (± 0.05 in. H ₂ O).
Pressure drop across the LFE matrix	EDP	kPa (in. H ₂ O)	± 0.001 kPa (± 0.005 in. H ₂ O).
Air temperature at CVS pump inlet	PTI	°C (°F)	± 0.25 °C (± 0.45 °F).
Pressure depression at CVS pump inlet	PPI	kPa (in. Fluid)	± 0.021 kPa (± 0.046 in. Fluid).
Specific gravity of manometer fluid (1.75 oil)	Sp. Gr.
Pressure head at CVS pump outlet	PPO	kPa (in. Fluid)	± 0.021 kPa (± 0.046 in. Fluid).
Air temperature at CVS pump outlet (optional)	PTO	°C (°F)	± 0.25 °C (± 0.45 °F).
Pump revolutions during test period	N	Revs	± 1 Rev.
Elapsed time for test period	t	s	± 0.05 s.

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(5) After the system has been connected as shown in Figure F78-5, set the variable restrictor in the wide open position and run the CVS pump for twenty minutes. Record the calibration data.

(6) Reset the restrictor valve to a more restricted condition in an increment of pump inlet depression (about 1.0 kPa (4" H₂O)) that will yield a minimum of six data points for the total calibration. Allow the system to stabilize for 3 minutes and repeat the data acquisition.

(7) *Data analysis:* (i) The air flow rate, Q_s , at each test point is calculated from the flowmeter data using the manufacturer's prescribed method.

(ii) The air flow rate is then converted to pump flow, V_o , per revolution at absolute pump inlet temperature and pressure.

$$V_o = (Q_s/n) \times (T_p/293.15) \times (101.325/P_p)$$

where:

V_o = Pump flow, m³/revolution (ft³/revolution) at T_p , P_p

Q_s = Meter air flow rate in standard cubic metres per minute, standard conditions are 20 °C, 101.325 kPa (68 °F, 29.92 in. Hg).

n = Pump speed in revolutions per minute.

T_p = Pump inlet temperature, K(R) = PTI + 273.15 for English units, T_p = PTI + 459.67

P_p = Absolute pump inlet pressure, kPa (in. Hg) = $P_B - PPI$ for English units, $P_p = P_B - PPI$ (SP. GR./13.57)

where:

P_B = barometric pressure, kPa (in. Hg)

PPI = Pump inlet depression, kPa (in. fluid)

SP. GR. = Specific gravity of manometer fluid relative to water.

(iii) The correlation function at each test point is then calculated from the calibration data:

ER06OC93.103

where:

X_o = correlation function.

P_p = The pressure differential from pump inlet to pump outlet, kPa (in. Hg) = $P_e - P_p$

P_e = Absolute pump outlet pressure, kPa
(in. Hg) = P_B + PPO for English units,
 $P_e = P_B + \text{PPO}(\text{SP. GR.}/13.57)$

where:

PPO = Pressure head at pump outlet, kPa
(in. fluid)

(iv) A linear least squares fit is performed to generate the calibration equations which have the forms:

$$V_o = D_o - M(X_o)$$

$$n = A - B(P_p)$$

D_o , M , A , and B are the slope-intercept constants describing the lines.

(8) A CVS system that has multiple speeds shall be calibrated on each speed used. The calibration curves generated for the ranges will be approximately parallel and the intercept values, D_o , will increase as the pump flow range decreases.

(9) If the calibration has been performed carefully, the calculated values from the equation will be within ± 0.50 percent of the measured value of V_o . Values of M will vary from one pump to another, but values of D_o for pumps of the same make, model, and range should agree within ± 3 percent of each other. Particulate influx from use will

cause the pump slip to decrease as reflected by lower values for M . Calibrations should be performed at pump startup and after major maintenance to assure the stability of the pump slip rate. Analysis of mass injection data will also reflect pump slip stability.

(b) *CFV calibration.* (1) Calibration of the Critical Flow Venturi (CFV) is based upon the flow equation for a critical venturi. Gas flow is a function of inlet pressure and temperature:

ER06OC93.104

where:

Q_s = Flow
 K_v = Calibration coefficient
 P = Absolute pressure
 T = Absolute temperature

The calibration procedure described below establishes the value of the calibration coefficient at measured values of pressure, temperature and air flow.

(2) The manufacturer's recommended procedure shall be followed for calibrating electronic portions of the CFV.

(3) Measurements necessary for flow calibration are as follows:

CALIBRATION DATA MEASUREMENTS

Parameter	Symbol	Units	Tolerances
Barometric pressure (corrected)	P_B	kPa (in. Hg)	± 0.03 kPa (± 0.01 in. Hg).
Air temperature, flowmeter	ETI	$^{\circ}\text{C}$ ($^{\circ}\text{F}$)	± 0.15 $^{\circ}\text{C}$ (± 0.27 $^{\circ}\text{F}$).
Pressure depression upstream of LFE	EPI	kPa (in. H_2O)	± 0.01 kPa (± 0.05 in. H_2O).
Pressure drop across LFE matrix	EDP	kPa (in. H_2O)	± 0.001 kPa (± 0.005 in. H_2O).
Air flow	Q_s	m^3/min . (ft 3 /min)	$\pm 0.5\%$.
CFV inlet depression	PPI	kPa (in. fluid)	± 0.02 kPa (± 0.05 in. fluid).
Temperature at venturi inlet	T_v	$^{\circ}\text{C}$ ($^{\circ}\text{F}$)	± 0.25 $^{\circ}\text{C}$ (± 0.45 $^{\circ}\text{F}$).
Specific gravity of manometer fluid (1.75 oil)	Sp. Gr..		

ER06OC93.179

(4) Set up equipment as shown in Figure F78-6 and check for leaks. Any leaks between the flow measuring device and the critical flow venturi will seriously affect the accuracy of the calibration.

(5) Set the variable flow restrictor to the open position, start the blower and

allow the system to stabilize. Record data from all instruments.

(6) Vary the flow restrictor and make at least 8 readings across the critical flow range of the venturi.

(7) *Data analysis.* The data recorded during the calibration are to be used in the following calculations:

(i) The air flow rate, Q_s , at each test point is calculated from the flow meter data using the manufacturer's prescribed method.

(ii) Calculate values of the calibration coefficient for each test point:

ER06OC93.201

where:

Q_s = Flow rate, standard conditions are 20 °C, 101.325 kPa (68 °F, 29.92 in. Hg)

T_v = Temperature at venturi inlet, K(R).

P_v = Pressure at venturi inlet, kPa (mm Hg) = $P_B - PPI$ for English units $P_v = P_B - PPI$ (SP. GR./13.57).

where:

PPI = Venturi inlet pressure depression, kPa (in. fluid).

SP. GR. = Specific gravity of manometer fluid, relative to water.

(iii) Plot K_v as a function of venturi inlet depression. For sonic flow, K_v will have a relatively constant value. As pressure decreases (vacuum increases), the venturi becomes unchoked and K_v decreases (is no longer constant). See Figure F78-7.

(iv) For a minimum of 8 points in the critical region calculate an average K_v and the standard deviation.

(v) If the standard deviation exceeds 0.3 percent of the average K_v take corrective action.

(c) *CVS System Verification.* The following "gravimetric" technique can be used to verify that the CVS and analytical instruments can accurately measure a mass of gas that has been injected into the system. (Verification can also be accomplished by constant flow metering using critical flow orifice devices.)

(1) Obtain a small cylinder that has been charged with pure propane or carbon monoxide gas (caution—carbon monoxide is poisonous).

(2) Determine a reference cylinder weight to the nearest 0.01 grams.

(3) Operate the CVS in the normal manner and release a quantity of pure propane or carbon monoxide into the system during the sampling period (approximately 5 minutes).

(4) The calculations of § 86.544 are performed in the normal way except in the case of propane. The density of propane (0.6109 kg/m³/carbon atom (17.30 g/ft³/carbon atom)) is used in place of the

density of exhaust hydrocarbons. In the case of carbon monoxide, the density of 1.164 kg/m³ (32.97 g/ft³) is used.

(5) The gravimetric mass is subtracted from the CVS measured mass and then divided by the gravimetric mass to determine the percent accuracy of the system.

(6) The cause for any discrepancy greater than ±2 percent must be found and corrected.

[42 FR 1137, Jan. 5, 1977, as amended at 42 FR 56738, Oct. 28, 1977]

§ 86.519-90 Constant volume sampler calibration.

(a) The CVS (Constant Volume Sampler) is calibrated using an accurate flowmeter and restrictor valve. Measurements of various parameters are made and related to flow through the unit. Procedures used by EPA for both PDP (Positive Displacement Pump) and CFV (Critical Flow Venturi) are outlined below. Other procedures yielding equivalent results may be used if approved in advance by the Administrator. After the calibration curve has been obtained, verification of the entire system can be performed by injecting a known mass of gas into the system and comparing the mass indicated by the system to the true mass injected. An indicated error does not necessarily mean that the calibration is wrong, since other factors can influence the accuracy of the system, e.g., analyzer calibration. A verification procedure is found in paragraph (d) of this section.

(b) *PDP calibration.* (1) The following calibration procedures outlines the equipment, the test configuration, and the various parameters which must be measured to establish the flow rate of the constant volume sampler pump. All the parameters related to the pump are simultaneously measured with the parameters related to a flowmeter which is connected in series with the pump. The calculated flow rate (at pump inlet absolute pressure and temperature) can then be plotted versus a correlation function which is the value of a specific combination of pump parameters. The linear equation which relates the pump flow and the correlation function is then determined. In the event that a

CVS has a multiple speed drive, a calibration for each range must be performed.

(2) This calibration procedure is based on the measurement of the absolute values of the pump and flowmeter parameters that relate the flow rate at each point. Three conditions must be maintained to assure the accuracy and integrity of the calibration curve. First, the pump pressures should be measured at taps on the pump rather than at the external piping on the pump inlet and outlet. Pressure taps that are mounted at the top center and bottom center of the pump drive headplate are exposed to the actual pump cavity pressures, and therefore reflect the absolute pressure differentials. Secondly, temperature stability must be maintained during the calibration. The laminar flowmeter is sen-

sitive to inlet temperature oscillations which cause the data points to be scattered. Gradual changes ($\pm 1^\circ\text{C}$ ($\pm 1.8^\circ\text{F}$)) in temperature are acceptable as long as they occur over a period of several minutes. Finally, all connections between the flowmeter and the CVS pump must be absolutely void of any leakage.

(3) During an exhaust emission test the measurement of these same pump parameters enables the user to calculate the flow rate from the calibration equation.

(4) Connect a system as shown in Figure F78-5. Although particular types of equipment are shown, other configurations that yield equivalent results may be used if approved in advance by the Administrator. For the system indicated, the following data with given accuracy are required:

CALIBRATION DATA MEASUREMENTS

Parameter	Symbol	Units	Tolerances
Barometric pressure corrected	P _B	kPa (in. Hg)	± 0.03 kPa (± 0.01 in. Hg)
Ambient temperature	T _A	$^\circ\text{C}$ ($^\circ\text{F}$)	$\pm 0.3^\circ\text{C}$ ($\pm 0.54^\circ\text{F}$)
Air Temperature into LFE	ETI	$^\circ\text{C}$ ($^\circ\text{F}$)	$\pm 0.15^\circ\text{C}$ ($\pm 0.27^\circ\text{F}$)
Pressure depression upstream of LFE	EPI	kPa (in. H ₂ O)	± 0.01 kPa (± 0.05 in. H ₂ O)
Pressure drop across the LFE matrix	EDP	kPa (in. H ₂ O)	± 0.001 kPa (± 0.005 in. H ₂ O)
Air temperature at CVS pump inlet	PTI	$^\circ\text{C}$ ($^\circ\text{F}$)	$\pm 0.25^\circ\text{C}$ ($\pm 0.45^\circ\text{F}$)
Pressure depression at CVS pump inlet	PPI	kPa (in. Fluid)	± 0.021 kPa (± 0.046 in. Fluid)
Specific gravity of manometer fluid (1.75 oil)	Sp Gr
Pressure head at CVS pump outlet	PPO	kPa (in. Fluid)	± 0.21 kPa (± 0.046 in. Fluid)
Air temperature at CVS pump outlet (optional)	PTO	$^\circ\text{C}$ ($^\circ\text{F}$)	$\pm 0.25^\circ\text{C}$ ($\pm 0.45^\circ\text{F}$)
Pump revolutions during test period	N	Revs	± 1 Rev.
Elapsed time for test period	t	sec.	± 0.05 sec.

(5) After the system has been connected as shown in Figure F78-6, set the variable restrictor in the wide open position and run the CVS pump for twenty minutes. Record the calibration data.

(6) Reset the restrictor valve to a more restricted condition in an increment of pump inlet depression (about 1.0 kPa (4 in. H₂O)) that will yield a minimum of six data points for the total calibration. Allow the system to stabilize for 3 minutes and repeat the data acquisition.

(7) Data analysis:

(i) The air flow rate, Q_s , at each test point is calculated from the flowmeter data using the manufacturers' prescribed method.

(ii) The air flow rate is then converted to pump flow, V_o in m³ per revo-

lution at absolute pump inlet temperature and pressure.

$$V_o = (Q_s/n) \times (T_p/273) \times (101.3/P_p)$$

Where:

(A) V_o = Pump flow, m³/rev (ft³/rev) at T_p , P_p .

(B) Q_s = Meter air flow rate in standard cubic meters per minute; standard conditions are 20°C , 101.3 kPa (68 $^\circ\text{F}$, 29.92 in. Hg).

(C) n = Pump speed in revolutions per minute.

(D)(1) T_p = Pump inlet temperature, ($^\circ\text{K}$) = PTI + 273.

(2) For English units, $T_p = \text{PTI} + 460$.

(E)(1) P_p = Absolute pump inlet pressure, kPa (in. Hg) = $P_B - \text{PPI}$.

(2) For English units, $P_p = P_B - \text{PPI}(\text{SP.GR.}/13.57)$.

Where:

(F) P_B = barometric pressure, kPa (in. Hg.).

(G) PPI = Pump inlet depression, kPa (in. fluid).

(H) SP.GR. = Specific gravity of manometer fluid relative to water.

(iii) The correlation function at each test point is then calculated from the calibration data:

ER06OC93.105

Where:

(A) X_o = correlation function.

(B) ΔP_p = The pressure differential from pump inlet to pump outlet, kPa (in. Hg) = $P_e - P_p$.

(C)(1) P_e = Absolute pump outlet pressure, kPa (in. Hg) = $P_B + PPO$.

(2) For English units, $P_e = P_B + PPO(SP.GR./13.57)$.

Where:

(D) PPO = Pressure head at pump outlet, kPa (in. fluid).

(iv) A linear least squares fit is performed to generate the calibration equations which have the forms:

$$V_o = D_o - M(X_o)$$

$$n = A - B(\Delta P_p)$$

D_o , M , A , and B are the slope-intercept constants, describing the lines.

(8) A CVS system that has multiple speeds shall be calibrated on each speed used. The calibration curves generated for the ranges will be approximately parallel and the intercept values, D_o , will increase as the pump flow range decreases.

(9) If the calibration has been performed carefully, the calculated values from the equation will be within ± 0.50 percent of the measured value of V_o . Values of M will vary from one pump to another, but values of D_o for pumps of the same make, model, and range should agree within ± 3 percent of each other. Particulate influx from use will cause the pump slip to decrease as reflected by lower values for M . Calibrations should be performed at pump startup and after major maintenance to assure the stability of the pump slip rate. Analysis of mass injection data will also reflect pump slip stability.

(c) *CFV calibration.* (1) Calibration of the Critical Flow Venturi (CFV) is based upon the flow equation for a critical venturi. Gas flow is a function of inlet pressure and temperature:

ER06OC93.106

Where:

(i) Q_s = Flow.

(ii) K_v = Calibration coefficient.

(iii) P = Absolute pressure.

(iv) T = Absolute temperature.

The calibration procedure described below establishes the value of the calibration coefficient at the measured values of pressure, temperature and air flow.

(2) The manufacturer's recommended procedure shall be followed for calibrating electronic portions of the CFV.

(3) Measurements necessary for flow calibration are as follows:

CALIBRATION DATA MEASUREMENTS

Parameter	Symbol	Units	Tolerances
Barometric pressure (corrected)	P_B	kPa (in. Hg)	± 0.03 kPa (± 0.01 in. Hg)
Air temperature, flowmeter	ETI	$^{\circ}\text{C}$ ($^{\circ}\text{F}$)	± 0.15 $^{\circ}\text{C}$ (± 0.27 $^{\circ}\text{F}$)
Pressure depression upstream of LFE	EPI	kPa (in. H_2O)	± 0.01 kPa (± 0.05 in. H_2O)
Pressure drop across LFE matrix	EDP	kPa (in. H_2O)	± 0.001 kPa (± 0.005 in. H_2O)
Air flow	Q_s	m^3/min (ft^3/min)	$\pm 0.5\%$
CFV inlet depression	PPI	kPa (in. fluid)	± 0.02 kPa (± 0.05 in. fluid)
Temperature at venturi inlet	T_v	$^{\circ}\text{C}$ ($^{\circ}\text{F}$)	± 0.25 $^{\circ}\text{C}$ (± 0.45 $^{\circ}\text{F}$)
Specific gravity of manometer fluid (1.75 oil)	Sp Gr

(4) Set up equipment as shown in Figure F78-6 and check for leaks. Any leaks between the flow measuring device and the critical flow venturi will seriously affect the accuracy of the calibration.

(5) Set the variable flow restrictor to the open position, start the blower and allow the system to stabilize. Record data from all instruments.

(6) Vary the flow restrictor and make at least 8 readings across the critical flow range of the venturi.

(7) *Data analysis.* The data recorded during the calibration are to be used in the following calculations:

(i) The air flow rate, Q_s , at each test point is calculated from the flowmeter data using the manufacturer's prescribed method.

(ii) Calculate values of the calibration coefficient for each test point:

ER06OC93.107

Where:

(A) Q_s = Flow rate in m³/minute, standard conditions are 20 °C, 101.3 kPa (68 °F, 29.92 in. Hg)

(B) T_v = Temperature at venturi inlet, °K(°R).

(C)(1) P_v = Pressure at venturi inlet, kPa (mm Hg) = $P_B - PPI$.

(2) *For English units*, $P_v = P_B - PPI$ (SP.GR./13.57).

Where:

(D) PPI = Venturi inlet pressure depression, kPa (in. fluid).

(E) SP.GR.=Specific gravity of manometer fluid, relative to water.

(iii) Plot K_v as a function of venturi inlet depression. For sonic flow, K_v will have a relatively constant value. As pressure decreases (vacuum increases), the venturi becomes unchoked and K_v decreases (is no longer constant). See Figure F78-7.

(iv) For a minimum of 8 points in the critical region, calculate an average K_v and the standard deviation.

(v) If the standard deviation exceeds 0.3 percent of the average K_v , take corrective action.

(d) *CVS system verification.* The following "gravimetric" technique can be used to verify that the CVS and analytical instruments can accurately measure a mass of gas that has been injected into the system. If the CVS and analytical system will be used only in the testing of gasoline-fueled vehicles, the system verification may be performed using either propane or carbon monoxide. If the CVS and analytical system will be used with methanol-fueled vehicles as well as gasoline-fueled vehicles, system verification

performance check must include a methanol check in addition to either the propane or carbon monoxide check. (Verification can also be accomplished by constant flow metering using critical flow orifice devices.)

(1) Obtain a small cylinder that has been charged with pure propane or carbon monoxide gas (CAUTION—carbon monoxide is poisonous).

(2) Determine a reference cylinder weight to the nearest 0.01 grams.

(3) Operate the CVS in the normal manner and release a quantity of pure propane or carbon monoxide into the system during the sampling period (approximately 5 minutes).

(4) Following completion of step (3) above (if methanol injection is required), continue to operate the CVS in the normal manner and release a known quantity of pure methanol (in gaseous form) into the system during the sampling period (approximately 5 minutes). This step does not need to be performed with each verification, provided that it is performed at least twice annually.

(5) The calculations of § 86.544 are performed in the normal way except in the case of propane. The density of propane (0.6109 kg/m³/carbon atom (17.30 g/ft³/carbon atom)) is used in place of the density of exhaust hydrocarbons. In the case of carbon monoxide, the density of 1.164 kg/m³ (32.97 g/ft³) is used. In the case of methanol, the density of 1.332 kg/m³ (37.71 g/ft³) is used.

(6) The gravimetric mass is subtracted from the CVS measured mass and then divided by the gravimetric mass to determine the percent accuracy of the system.

(7) The cause for any discrepancy greater than ±2 percent must be found and corrected. The Administrator, upon request, may waive the requirement to comply with ±2 percent methanol recovery tolerance, and instead require compliance with a higher tolerance (not to exceed ±6 percent), provided that:

(i) The Administrator determines that compliance with the specified tolerance is not practically feasible; and

(ii) The manufacturer makes information available to the Administrator which indicates that the calibration tests and their results are consistent

with good laboratory practice, and that the results are consistent with the results of calibration testing conducted by the Administrator.

[54 FR 14546, Apr. 11, 1989, as amended at 60 FR 34355, June 30, 1995]

§ 86.521-90 Hydrocarbon analyzer calibration.

(a) The FID hydrocarbon analyzer shall receive the following initial and periodic calibration. The HFID used with methanol-fueled vehicles shall be operated at 235 °F±15 °F (113 °C±8 °C).

(b) *Initial and periodic optimization of detector response.* Prior to its introduction into service and at least annually thereafter, the FID hydrocarbon analyzer shall be adjusted for optimum hydrocarbon response. Analyzers used with petroleum fuels and liquefied petroleum gas-fuel shall be optimized using propane. Analyzers used with natural gas-fuel for measurement of hydrocarbons shall be optimized using methane. If a single analyzer is used for all measurements, it shall be optimized using propane and its response factor for methane shall be determined and accounted for in measurements of total hydrocarbons from natural gas-fuel. Alternate methods yielding equivalent results may be used, if approved in advance by the Administrator.

(1) Follow the manufacturer's instructions or good engineering practice for instrument startup and basic operating adjustment using the appropriate FID fuel and zero-grade air.

(2) Optimize on the most common operating range. Introduce into the analyzer a propane (methane as appropriate) in air mixture (methanol in air mixture for methanol-fueled vehicles when optional methanol calibrated FID procedure is used during the 1990 through 1994 model year) with a propane (or methane or methanol as appropriate) concentration equal to approximately 90 percent of the most common operating range.

(3) Select an operating FID fuel flow rate that will give near maximum response and least variation in response with minor fuel flow variations.

(4) To determine the optimum air flow, use the FID fuel flow setting determined above and vary air flow.

(5) After the optimum flow rates have been determined, record them for future reference.

(c) *Initial and periodic calibration.* Prior to its introduction into service and monthly thereafter the FID hydrocarbon analyzer shall be calibrated on all normally used instrument ranges, and, if applicable, the methanol response factor shall be determined (paragraph (d) of this section). Use the same flow rate as when analyzing sample.

(1) Adjust analyzer to optimize performance.

(2) Zero the hydrocarbon analyzer with zero grade air.

(3) Calibrate on each normally used operating range with propane in air (or methanol or methane in air as appropriate) calibration gases having nominal concentrations of 15, 30, 45, 60, 75 and 90 percent of that range. For each range calibrated, if the deviation from a least squares best-fit straight line is two percent or less of the value at each data point, concentration values may be calculated by use of a single calibration factor for that range. If the deviation exceeds two percent at any point, the best-fit non-linear equation which represents the data to within two percent of each test point shall be used to determine concentration.

(d) *FID response factor to methanol.* When the FID analyzer is to be used for the analysis of hydrocarbon samples containing methanol, the methanol response factor of the analyzer shall be established. The methanol response factor shall be determined at several concentrations in the range of concentrations in the exhaust sample, using either bag samples or gas bottles meeting the requirements of § 86.514.

(1) The bag sample, if used, of methanol for analysis in the FID shall be prepared using the apparatus shown in Figure F90-4. A known volume of methanol is injected, using a microliter syringe, into the heated mixing zone (250 °F (121 °C)) of the apparatus. The methanol is vaporized and swept into the sample bag with a known volume of zero grade air measured by a gas flow meter meeting the performance requirements of § 86.120.

ER06OC93.180

(2) The bag sample is analyzed using the FID.

(3) The FID response factor, r , is calculated as follows:

$$r = \text{FID}_{\text{ppm}} / \text{SAM}_{\text{ppm}}$$

Where:

(i) r = FID response factor.

- (ii) FID_{ppm} = FID reading, ppmC.
- (iii) SAM_{ppm} = methanol concentration in the sample bag, or gas bottle, in ppmC. SAM_{ppm} for sample bags:

ER06OC93.108

Where:

- (iv) 0.02406 = Volume of one mole at 101.3 kPa (29.92 in. Hg) and 20 °C (68 °F), m^3 .
- (v) Fuel injected = Volume of methanol injected, ml.
- (vi) Fuel Density = Density of methanol, 0.7914 g/ml
- (vii) Air volume = Volume of zero grade air, m^3
- (viii) Mol. Wt. CH_3OH = 32.04
- (e) *FID response factor to methane.*

When the FID analyzer is to be used for the analysis of natural gas-fueled motorcycle hydrocarbon samples, the methane response factor of the analyzer shall be established. To determine the total hydrocarbon FID response to methane, known methane in air concentrations traceable to National Institute of Standards and Technology (NIST) shall be analyzed by the FID. Several methane concentrations shall be analyzed by the FID in the range of concentrations in the exhaust sample. The total hydrocarbon FID response to methane is calculated as follows:

$$r_{CH_4} = FID_{ppm} / SAM_{ppm}$$

Where:

- (1) r_{CH_4} = FID response factor to methane.
- (2) FID_{ppm} = FID reading in ppmC.
- (3) SAM_{ppm} = the known methane concentration in ppmC.

[54 FR 14546, Apr. 11, 1989, as amended at 59 FR 48514, Sept. 21, 1994; 60 FR 34355, June 30, 1995]

§ 86.522-78 Carbon monoxide analyzer calibration.

(a) *Initial and periodic interference check.* Prior to its introduction into service and annually thereafter the NDIR carbon monoxide analyzer shall be checked for response to water vapor and CO_2 .

(1) Follow the manufacturer's instructions for instrument startup and operation. Adjust the analyzer to optimize performance on the most sensitive range.

(2) Zero the carbon monoxide analyzer with either zero grade air or zero grade nitrogen.

(3) Bubble a mixture of 3 percent CO_2 in N_2 through water at room temperature and record analyzer response.

(4) An analyzer response of more than 1 percent of full scale for ranges above 300 ppm full scale or of more than 3 ppm on ranges below 300 ppm full scale will require corrective action. (Use of conditioning columns is one form of corrective action which may be taken.)

(b) *Initial and periodic calibration.* Prior to its introduction into service and monthly thereafter the NDIR carbon monoxide analyzer shall be calibrated.

(1) Adjust the analyzer to optimize performance.

(2) Zero the carbon monoxide analyzer with either zero grade air or zero grade nitrogen.

(3) Calibrate on each normally used operating range with carbon monoxide in N_2 calibration gases having nominal concentrations of 15, 30, 45, 60, 75, and 90 percent of that range. Additional calibration points may be generated. For each range calibrated, if the deviation from a least-squares best-fit straight line is 2 percent or less of the value at each data point, concentration values may be calculated by use of a single calibration factor for that range. If the deviation exceeds 2 percent at any point, the best-fit non-linear equation which represents the data to within 2 percent of each test point shall be used to determine concentration.

§ 86.523-78 Oxides of nitrogen analyzer calibration.

(a) Prior to introduction into service and at least monthly thereafter, if oxides of nitrogen are measured, the chemiluminescent oxides of nitrogen analyzer must be checked for NO_2 to NO converter efficiency. Figure F78-8 is a reference for paragraphs (a) (1) through (11) of this section.

ER06OC93.181

(1) Follow the manufacturer's instructions for instrument startup and operation. Adjust the analyzer to optimize performance.

(2) Zero the oxides of nitrogen analyzer with zero grade air or zero grade nitrogen.

(3) Connect the outlet of the NO_x generator to the sample inlet of the oxides of nitrogen analyzer which has been set to the most common operating range.

(4) Introduce into the NO_x generator analyzer-system a NO in nitrogen (N₂) mixture with a NO concentration equal to approximately 80 percent of the most common operating range. The

NO₂ content of the gas mixture shall be less than 5 percent of the NO concentration.

(5) With the oxides of nitrogen analyzer in the NO mode, record the concentration of NO indicated by the analyzer.

(6) Turn on the NO_x generator O₂ (or air) supply and adjust the O₂ (or air) flow rate so that the NO indicated by the analyzer is about 10 percent less than indicated in step 5. Record the concentration of NO in this NO + O₂ mixture.

(7) Switch the NO_x generator to the generation mode and adjust the generation rate so that the NO measured on

the analyzer is 20 percent of that measured in step 5. There must be at least 10 percent unreacted NO at this point. Record the concentration of residual NO.

(8) Switch the oxides of nitrogen analyzer to the NO_x mode and measure total NO_x. Record this value.

(9) Switch off the NO_x generation but maintain gas flow through the system. The oxides of nitrogen analyzer will indicate the NO_x in the NO + O₂ mixture. Record this value.

(10) Turn off the NO_x generator O₂ (or air) supply. The analyzer will now indicate the NO_x in the original NO in N₂ mixture. This value should be no more than 5 percent above the value indicated in step 4.

(11) Calculate the efficiency of the NO_x converter by substituting the concentrations obtained into the following equation:

$$\text{Percent Efficiency} = [1 + (a-b)/(c-d)] \times 100$$

where:

a = concentration obtained in step (8).

b = concentration obtained in step (9).

c = concentration obtained in step (6).

d = concentration obtained in step (7).

If converter efficiency is not greater than 90 percent corrective action will be required.

(b) *Initial and periodic calibration.* Prior to its introduction into service and monthly thereafter, if oxides of nitrogen are measured, the chemiluminescent oxides of nitrogen analyzer shall be calibrated on all normally used instrument ranges. Use the same flow rate as when analyzing samples. Proceed as follows:

(1) Adjust analyzer to optimize performance.

(2) Zero the oxides of nitrogen analyzer with zero grade air or zero grade nitrogen.

(3) Calibrate on each normally used operating range with NO in N₂ calibration gases with nominal concentrations of 50 and 100 percent of that range. Additional calibration points may be generated.

(c) When testing methanol-fueled motorcycles, it may be necessary to clean the analyzer frequently to prevent in-

terference with NO_x measurements (see EPA/600/S3-88/040).

[42 FR 1137, Jan. 5, 1977, as amended at 52 FR 47870, Dec. 16, 1987; 58 FR 58423, Nov. 1, 1993; 60 FR 34357, June 30, 1995]

§ 86.524-78 Carbon dioxide analyzer calibration.

(a) Prior to its introduction into service and monthly thereafter the NDIR carbon dioxide analyzer shall be calibrated:

(1) Follow the manufacturer's instructions for instrument startup and operation. Adjust the analyzer to optimize performance.

(2) Zero the carbon dioxide analyzer with either zero grade air or zero grade nitrogen.

(3) Calibrate on each normally used operating range with carbon dioxide in N₂ calibration gases with nominal concentrations of 15, 30, 45, 60, 75, and 90 percent of that range. Additional calibration points may be generated. For each range calibrated, if the deviation from a least-squares best-fit straight line is 2 percent or less of the value at each data point, concentration values may be calculated by use of a single calibration factor for that range. If the deviation exceeds 2 percent at any point, the best-fit non-linear equation which represents the data to within 2 percent of each test point shall be used to determine concentration.

(b) [Reserved]

§ 86.526-90 Calibration of other equipment.

Other test equipment used for testing shall be calibrated as often as required by the manufacturer or as necessary according to good practice. Specific equipment requiring calibration is the gas chromatograph and flame ionization detector used in measuring methanol and the high pressure liquid chromatograph (HPLC) and ultraviolet detector for measuring formaldehyde.

[54 FR 14551, Apr. 11, 1989]

§ 86.527-90 Test procedures, overview.

(a) The procedures described in this and subsequent sections are used to determine the conformity of motorcycles with the standards set forth in subpart E of this part.

(b) The overall test consists of prescribed sequences of fueling, parking, and operating conditions.

(c) The exhaust emission test is designed to determine hydrocarbon (gasoline-fueled, natural gas-fueled and liquefied petroleum gas-fueled motorcycles), methanol, formaldehyde, and hydrocarbon (methanol-fueled motorcycles), carbon monoxide and oxides of nitrogen mass emissions while simulating an average trip in an urban area. The test consists of engine startups and motorcycle operation on a chassis dynamometer, through a specified driving schedule. A proportional part of the diluted exhaust emissions is collected continuously for subsequent analysis, using a constant volume (variable dilution) sampler.

(d) Except in cases of component malfunction or failure, all emission control systems installed on or incorporated in a new motorcycle shall be functioning during all procedures in this subpart. Maintenance to correct component malfunction or failure shall be authorized in accordance with subpart E of this part.

(e) Background concentrations are measured for all species for which emissions measurements are made. For exhaust testing, this requires sampling and analysis of the dilution air. (When testing methanol-fueled motorcycles, manufacturers may choose not to measure background concentrations of methanol and/or formaldehyde, and then assume that the concentrations are zero during calculations.)

[54 FR 14551, Apr. 11, 1989, as amended at 59 FR 48515, Sept. 21, 1994; 60 FR 34357, June 30, 1995]

§ 86.528-78 Transmissions.

(a) Vehicles equipped with transfer cases, multiple sprockets, etc., shall be tested in the manufacturer's recommended configuration for street or highway use. If more than one configuration is recommended or if the recommendation is deemed unreasonable by the Administrator, the Administrator will specify the test configuration.

(b) All tests shall be conducted with automatic transmissions in "Drive" (highest gear). Automatic clutch-torque converter transmissions may be

shifted as manual transmissions at the option of the manufacturer.

(c) Idle modes shall be run with automatic transmissions in "Drive" and the wheels braked, manual transmission shall be in gear with the clutch disengaged; except first idle, see §§ 86.536 and 86.537.

(d) The vehicle shall be driven with minimum throttle movement to maintain the desired speed. No simultaneous use of brake and throttle shall be permitted.

(e) Acceleration modes shall be driven smoothly. Automatic transmissions shall shift automatically through the normal sequence of gears; manual transmissions shall be shifted as recommended by the manufacturer to the ultimate purchaser (unless determined to be unreasonable by the Administrator) with the operator closing the throttle during each shift and accomplishing the shift with minimum time. If the vehicle cannot accelerate at the specified rate, the vehicle shall be operated with the throttle fully opened until the vehicle speed reaches the value prescribed for that time in the driving schedule.

(f) The deceleration modes shall be run in gear using brakes or throttle as necessary to maintain the desired speed. Manual transmission vehicles shall be downshifted using the same shift points as when upshifting or as recommended by the manufacturer in the vehicle owner's manual. All downshifts shall be made smoothly, disengaging the clutch while shifting and engaging the clutch once the lower gear has been selected. For those modes which require the vehicle to decelerate to zero, manual transmission clutches shall be disengaged when the speed drops below 15 km/h (9.3 mph) for vehicles with engine displacements equal to or greater than 280 cc (17.1 cu. in.), when the speed drops below 10 km/h (6.2 mph) for vehicles with engine displacements less than 280 cc (17.1 cu. in.), when engine roughness is evident, or when engine stalling is imminent.

(g) If downshifting during deceleration is not permitted in the vehicle owner's manual, manual transmissions will be downshifted at the beginning of or during a power mode if recommended by the manufacturer or if

the engine obviously is lugging. For those modes which require these vehicles to decelerate to zero, manual transmission clutches shall be disengaged when the speed drops below 25 km/h (15.5 mph) for vehicles with engine displacement equal to or greater than 280 cc (17.1 cu. in.), when the speed drops below 20 km/h (12.4 mph) for vehicles with engine displacements less than 280 cc (17.1 cu. in.), when engine roughness is evident, or when engine stalling is imminent. While the clutch is disengaged and during these deceleration modes, the vehicle shall be shifted to the appropriate gear for starting the next mode.

(h) If shift speeds are not recommended by the manufacturer, manual transmission vehicles shall be shifted as follows:

(1) For Class I and II motorcycles:

Shift	Speed
1st to 2d gear	19 km/h (11.8 mi/h).
2d to 3d gear	33 km/h (20.5 mi/h).
3d to 4th gear	44 km/h (27.3 mi/h).
4th to 5th gear	53 km/h (32.9 mi/h).

(2) For Class III motorcycles:

Shift	Speed
1st to 2d gear	30 km/h (18.6 mi/h).
2d to 3d gear	45 km/h (28.0 mi/h).
3d to 4th gear	60 km/h (37.3 mi/h).
4th to 5th gear	75 km/h (46.6 mi/h).

(3) Higher gears may be used at the manufacturer's option.

§ 86.529-78 Road load force and inertia weight determination.

(a) Road load as a function of speed is given by the following equation:

$$F = A + CV^2$$

The values for coefficients A and C and the test inertia are given in Figure F78-9. Velocity (V) is in km/h and force (F) is in newtons. The forces given by this equation shall be simulated to the best ability of the equipment being used.

(b) The inertia given in Figure F78-9 shall be used. Motorcycles with loaded vehicle mass outside these limits shall be tested at an equivalent inertial mass and road load force specified by the Administrator.

FIGURE F78-9

Loaded vehicle mass (kg)	Equivalent inertial mass (kg)	Force coefficients		Force at 65 km/h (nt)	70 to 60 km/h coastdown calibration times		
		A (nt)	C (nt/(km/h) ²)		Target time (sec)	Allowable tolerance	
						Longest time (sec)	Shortest time (sec)
95–105	100	0.0	0.224	94.8	2.95	3.1	2.8
106–115	110	0.82	.0227	96.8	3.18	3.3	3.0
116–125	120	1.70	.0230	98.8	3.39	3.6	3.2
126–135	130	2.57	.0233	100.9	3.60	3.8	3.4
136–145	140	3.44	.0235	102.9	3.80	4.0	3.6
146–155	150	4.32	0.230	104.9	3.99	4.2	3.8
156–165	160	5.19	.0241	107.0	4.10	4.4	4.0
166–175	170	6.06	.0244	109.0	4.36	4.6	4.2
176–185	180	6.94	.0246	111.0	4.53	4.7	4.3
186–195	190	7.81	.0249	113.1	4.69	4.9	4.5
196–205	200	8.69	.0252	115.1	4.85	5.1	4.6
206–215	210	9.56	.0255	117.1	5.00	5.2	4.8
216–225	220	10.43	.0257	119.2	5.15	5.4	4.9
226–235	230	11.31	.0260	121.2	5.30	5.5	5.1
236–245	240	12.18	.0263	123.2	5.43	5.7	5.2
246–255	250	13.06	.0266	125.3	5.57	5.8	5.4
256–265	260	13.93	.0268	127.3	5.70	5.9	5.5
266–275	270	14.80	.0271	129.3	5.82	6.1	5.6
276–285	280	15.68	.0274	131.4	5.95	6.2	5.7
286–295	290	16.55	.0277	133.4	6.06	6.3	5.8
296–305	300	17.43	.0279	135.4	6.18	6.4	6.0
306–315	310	18.39	.0282	137.5	6.29	6.5	6.1
316–325	320	19.17	.0285	139.5	6.40	6.6	6.2
326–335	330	30.05	.0288	141.6	6.50	6.7	6.3
336–345	340	20.92	.0290	143.6	6.60	6.8	6.4
346–355	350	21.80	.0293	145.6	6.70	6.9	6.5
356–365	360	22.67	.0296	147.7	6.80	7.0	6.6
366–375	370	23.54	.0299	149.7	6.89	7.1	6.7
376–385	380	24.42	.0301	151.7	6.98	7.2	6.8

FIGURE F78-9—Continued

Loaded vehicle mass (kg)	Equivalent inertial mass (kg)	Force coefficients		Force at 65 km/h (nt)	70 to 60 km/h coastdown calibration times		
		A (nt)	C (nt/(km/h) ²)		Target time (sec)	Allowable tolerance	
						Longest time (sec)	Shortest time (sec)
386–395	390	25.29	.0304	153.8	7.07	7.3	6.9
396–405	400	26.17	.0307	155.8	7.16	7.4	6.9
406–415	410	27.04	.0310	157.8	7.24	7.5	7.0
416–425	420	27.91	.0312	159.9	7.33	7.6	7.1
426–435	430	28.79	.0315	161.9	7.41	7.6	7.2
436–445	440	29.66	.0317	163.7	7.49	7.7	7.3
446–455	450	30.54	.0318	164.9	7.61	7.8	7.4
456–465	460	31.41	.0319	166.0	7.73	8.0	7.5
466–475	470	32.28	.0319	167.1	7.84	8.1	7.6
476–485	480	33.16	.0320	168.3	7.95	8.2	7.7
486–495	490	34.03	.0320	169.4	8.06	8.3	7.8
496–505	500	34.90	.0321	170.5	8.17	8.4	7.9
506–515	510	35.78	.0322	171.7	8.28	8.5	8.0
516–525	520	36.65	.0322	172.8	8.39	8.6	8.2
526–535	530	37.53	.0323	173.9	8.49	8.7	8.3
536–545	540	38.40	.0323	175.1	8.60	8.8	8.4
546–555	550	39.27	.0324	176.2	8.70	9.0	8.5
556–565	560	40.15	.0325	177.3	8.80	9.1	8.6
566–575	570	41.02	.0325	178.5	8.90	9.2	8.7
576–585	580	41.90	.0326	179.6	9.00	9.3	8.8
586–595	590	42.77	.0327	180.8	9.10	9.4	8.9
596–605	600	43.64	.0327	181.9	9.19	9.5	8.9
606–615	610	44.52	.0328	183.0	9.29	9.5	9.0
616–625	620	45.39	.0328	184.2	9.38	9.6	9.1
626–635	630	46.27	.0329	185.3	9.47	9.7	9.2
636–645	640	47.14	.0330	186.4	9.56	9.8	9.3
646–655	650	48.01	.0330	187.6	9.65	9.9	9.4
656–665	660	48.89	.0331	188.7	9.74	10.0	9.5
666–675	670	49.76	.0332	189.8	9.83	10.1	9.6
676–685	680	50.64	.0332	191.0	9.92	10.2	9.7
686–695	690	51.91	.0333	192.1	10.01	10.3	9.8
696–705	700	52.38	.0333	193.2	10.09	10.4	9.8
706–715	710	53.26	.0334	194.4	10.17	10.4	9.9
716–725	720	54.13	.0335	195.5	10.26	10.5	10.0
726–735	730	55.01	.0335	196.6	10.34	10.6	10.1
736–745	740	55.88	.0336	197.8	10.42	10.7	10.2
746–755	750	56.75	.0336	198.9	10.50	10.8	10.2
756–760	760	57.63	.0337	200.1	10.58	10.9	10.3

(c) The dynamometer shall be adjusted to reproduce the specified road load as determined by the most recent calibration. Alternatively, the actual vehicle road load can be measured and duplicated:

(1) Make at least 5 replicate coastdowns in each direction from 70 to 60 km/h on a smooth, level, track under balanced wind conditions. The driver must have a mass of 80±10 kg and be in the normal driving position. Record the coastdown time.

(2) Average the coastdown times. Adjust the dynamometer load so that the coastdown time is duplicated with the vehicle and driver on the dynamometer.

(3) Alternate procedures may be used if approved in advance by the Administrator.

§86.529-98 Road load force and inertia weight determination.

(a)(1) Road load as a function of speed is given by the following equation:

$$F = A + CV^2$$

(2) The values for coefficients A and C and the test inertia are given in Figure F98-9 of this section. Velocity V is in km/h and force (F) is in newtons. The forces given by the equation in paragraph (a)(1) of this section shall be simulated to the best ability of the equipment being used.

(b) The inertia given in Figure F98-9 shall be used. Motorcycles with loaded

vehicle mass outside these limits shall be tested at an equivalent inertial mass and road load force specified by the Administrator. Figure F98-9 follows:

FIGURE F98-9

Loaded vehicle mass (kg)	Equivalent inertial mass (kg)	Force coefficients		Force at 65 km/h (nt)	70 to 60 km/h coastdown calibration times		
		A (nt)	C (nt/(km/ h) ²)		Target time (sec)	Allowable tolerance	
						Longest time (sec)	Shortest time (sec)
95–105	100	0.0	.0224	94.8	2.95	3.1	2.8
106–115	110	0.82	.0227	96.8	3.18	3.3	3.0
116–125	120	1.70	.0230	98.8	3.39	3.6	3.2
126–135	130	2.57	.0233	100.9	3.60	3.8	3.4
136–145	140	3.44	.0235	102.9	3.80	4.0	3.6
146–155	150	4.32	.0238	104.9	3.99	4.2	3.8
156–165	160	5.19	.0241	107.0	4.10	4.4	4.0
166–175	170	6.06	.0244	109.0	4.36	4.6	4.2
176–185	180	6.94	.0246	111.0	4.53	4.7	4.3
186–195	190	7.81	.0249	113.1	4.69	4.9	4.5
196–205	200	8.69	.0252	115.1	4.85	5.1	4.6
206–215	210	9.56	.0255	117.1	5.00	5.2	4.8
216–225	220	10.43	.0257	119.2	5.15	5.4	4.9
226–235	230	11.31	.0260	121.2	5.30	5.5	5.1
236–245	240	12.18	.0263	123.2	5.43	5.7	5.2
246–255	250	13.06	.0266	125.3	5.57	5.8	5.4
256–265	260	13.93	.0268	127.3	5.70	5.9	5.5
266–275	270	14.80	.0271	129.3	5.82	6.1	5.6
276–285	280	15.68	.0274	131.4	5.95	6.2	5.7
286–295	290	16.55	.0277	133.4	6.06	6.3	5.8
296–305	300	17.43	.0279	135.4	6.18	6.4	6.0
306–315	310	18.30	.0282	137.5	6.29	6.5	6.1
316–325	320	19.17	.0285	139.5	6.40	6.6	6.2
326–335	330	20.05	.0288	141.6	6.50	6.7	6.3
336–345	340	20.92	.0290	143.6	6.60	6.8	6.4
346–355	350	21.80	.0293	145.6	6.70	6.9	6.5
356–365	360	22.67	.0296	147.7	6.80	7.0	6.6
366–375	370	23.54	.0299	149.7	6.89	7.1	6.7
376–385	380	24.42	.0301	151.7	6.98	7.2	6.8
386–395	390	25.29	.0304	153.8	7.07	7.3	6.9
396–405	400	26.17	.0307	155.8	7.16	7.4	6.9
406–415	410	27.04	.0310	157.8	7.24	7.5	7.0
416–425	420	27.91	.0312	159.9	7.33	7.6	7.1
426–435	430	28.79	.0315	161.9	7.41	7.6	7.2
436–445	440	29.66	.0317	163.7	7.49	7.7	7.3
446–455	450	30.54	.0318	164.9	7.61	7.8	7.4
456–465	460	31.41	.0319	166.0	7.73	8.0	7.5
466–475	470	32.28	.0319	167.1	7.84	8.1	7.6
476–485	480	33.16	.0320	168.3	7.95	8.2	7.7
486–495	490	34.03	.0320	169.4	8.06	8.3	7.8
496–505	500	34.90	.0321	170.5	8.17	8.4	7.9
506–515	510	35.78	.0322	171.7	8.28	8.5	8.0
516–525	520	36.65	.0322	172.8	8.39	8.6	8.2
526–535	530	37.53	.0323	173.9	8.49	8.7	8.3
536–545	540	38.40	.0323	175.1	8.60	8.8	8.4
546–555	550	39.27	.0324	176.2	8.70	9.0	8.5
556–565	560	40.15	.0325	177.3	8.80	9.1	8.6
566–575	570	41.02	.0325	178.5	8.90	9.2	8.7
576–585	580	41.90	.0326	179.6	9.00	9.3	8.8
586–595	590	42.77	.0327	180.8	9.10	9.4	8.9
596–605	600	43.64	.0327	181.9	9.19	9.5	8.9
606–615	610	44.52	.0328	183.0	9.29	9.5	9.0
616–625	620	45.39	.0328	184.2	9.38	9.6	9.1
626–635	630	46.27	.0329	185.3	9.47	9.7	9.2
636–645	640	47.14	.0330	186.4	9.56	9.8	9.3
646–655	650	48.01	.0330	187.6	9.65	9.9	9.4
656–665	660	48.89	.0331	188.7	9.74	10.0	9.5
666–675	670	49.76	.0332	189.8	9.83	10.1	9.6
676–685	680	50.64	.0332	191.0	9.92	10.2	9.7
686–695	690	51.51	.0333	192.1	10.01	10.3	9.8
696–705	700	52.38	.0333	193.2	10.09	10.4	9.8
706–715	710	53.26	.0334	194.4	10.17	10.4	9.9

FIGURE F98-9—Continued

Loaded vehicle mass (kg)	Equivalent inertial mass (kg)	Force coefficients		Force at 65 km/h (nt)	70 to 60 km/h coastdown calibration times		
		A (nt)	C (nt/(km/ h) ²)		Target time (sec)	Allowable tolerance	
						Longest time (sec)	Shortest time (sec)
716–725	720	54.13	.0335	195.5	10.26	10.5	10.0
726–735	730	55.01	.0335	196.6	10.34	10.6	10.1
736–745	740	55.88	.0336	197.8	10.42	10.7	10.2
746–755	750	56.75	.0336	198.9	10.50	10.8	10.2
756–765	760	57.63	.0337	200.1	10.58	10.9	10.3
766–775	770	58.50	.0338	201.2	10.66	10.9	10.3
776–785	780	59.38	.0338	203.3	10.74	11.0	10.4
786–795	790	60.25	.0339	204.5	10.82	11.1	10.5
796–805	800	61.12	.0339	205.6	10.91	11.2	10.6
806–815	810	62.00	.0340	206.7	10.99	11.3	10.7
816–825	820	62.87	.0341	207.9	11.07	11.4	10.8
826–835	830	63.75	.0341	209.0	11.15	11.5	10.8
836–845	840	64.62	.0342	210.1	11.24	11.5	10.9
846–855	850	65.49	.0343	211.3	11.32	11.6	11.0
856–865	860	66.37	.0343	212.4	11.40	11.7	11.1
866–873	870	67.24	.0344	213.5	11.48	11.8	11.2

(c) The dynamometer shall be adjusted to reproduce the specified road load as determined by the most recent calibration. Alternatively, the actual vehicle road load can be measured and duplicated:

(1) Make at least 5 replicate coastdowns in each direction from 70 to 60 km/h on a smooth, level track under balanced wind conditions. The driver must have a mass of 80 ±10 kg and be in the normal driving position. Record the coastdown time.

(2) Average the coastdown times. Adjust the dynamometer load so that the coastdown time is duplicated with the vehicle and driver on the dynamometer.

(3) Alternate procedures may be used if approved in advance by the Administrator.

[63 FR 11849, Mar. 11, 1998]

§ 86.530-78 Test sequence, general requirements.

(a) Ambient temperature levels encountered by the test vehicle throughout the test sequence shall not be less than 20 °C (68 °F) nor more than 30 °C (86 °F). The vehicle shall be approximately level during the emission test to prevent abnormal fuel distribution.

(b) [Reserved]

§ 86.531-78 Vehicle preparation.

(a) The manufacturer shall provide additional fittings and adapters, as required by the Administrator * * *, such as * * * to accommodate a fuel drain at the lowest point possible in the tank(s) as installed on the vehicle and to provide for exhaust sample collection.

(b) [Reserved]

§ 86.532-78 Vehicle preconditioning.

(a) The vehicle shall be moved to the test area and the following operations performed:

(1) The fuel tank(s) shall be drained through the provided fuel tank(s) drain(s) and charged with the specified test fuel, § 86.513, to half the tank(s) capacity.

(2) The vehicle shall be placed, either by being driven or pushed, on a dynamometer and operated through one Urban Dynamometer Driving Schedule test procedure (see § 86.515 and appendix I). The vehicle need not be cold, and may be used to set dynamometer horsepower.

(b) Within five (5) minutes of completion of preconditioning, the vehicle shall be removed from the dynamometer and may be driven or pushed to the soak area to be parked. The vehicle shall be stored for not less than the following times prior to the cold start exhaust test.

	Hours
Class I	6
Class II	8
Class III	12

In no case shall the vehicle be stored for more than 36 hours prior to the cold start exhaust test.

§ 86.535-90 Dynamometer procedure.

(a) The dynamometer run consists of two tests, a "cold" start test and a "hot" start test following the "cold" start by 10 minutes. Engine startup (with all accessories turned off), operation over the driving schedule, and engine shutdown make a complete cold start test. Engine startup and operation over the first 505 seconds of the driving schedule complete the hot start test. The exhaust emissions are diluted with ambient air and a continuously proportional sample is collected for analysis during each phase. The composite samples collected in bags are analyzed for hydrocarbons, carbon monoxide, carbon dioxide, and, optionally, for oxides of nitrogen. A parallel sample of the dilution air is similarly analyzed for hydrocarbon, carbon monoxide, carbon dioxide, and, optionally, for oxides of nitrogen. Methanol and formaldehyde samples (exhaust and dilution air) are collected and analyzed for methanol-fueled vehicles (a single dilution air formaldehyde sample covering the total time of the test may be collected in place of individual test phases).

(b) [Reserved]

(c) The vehicle speed, as measured from the dynamometer roll, shall be used. A speed vs. time recording, as evidence of dynamometer test validity, shall be supplied on request of the Administrator.

(d) Practice runs over the prescribed driving schedule may be performed at test points, provided an emission sample is not taken, for the purpose of finding the minimum throttle action to maintain the proper speed-time relationship, or to permit sampling system adjustments.

(e) The drive wheel tires must be inflated to the manufacturer's recommended pressure, ± 15 kPa (± 2.2 psi). The drive wheel tire pressure shall be reported with the test results.

(f) If the dynamometer has not been operated during the two-hour period immediately preceding the test, it shall be warmed up for 15 minutes by operating at 50 km/h (31 mph) using a nontest vehicle, or as recommended by the dynamometer manufacturer.

(g) If the dynamometer horsepower must be adjusted manually, it shall be set within one hour prior to the exhaust emissions test phase. The test vehicle shall not be used to make this adjustment. Dynamometers using automatic control of preselectable power settings may be set anytime prior to the beginning of the emissions test.

(h) The driving distance, as measured by counting the number of dynamometer roll revolutions, shall be determined for the transient cold start, stabilized cold start, and transient hot start phases of the test.

[54 FR 14551, Apr. 11, 1989]

§ 86.536-78 Engine starting and re-starting.

(a)(1) The engine shall be started according to the manufacturer's recommended starting procedures. The initial 20 second idle period shall begin when the engine starts.

(2) *Choke operation.* (i) Vehicles equipped with automatic chokes shall be operated according to the instructions in the manufacturer's operating instructions or owner's manual including choke setting and "kick-down" from cold fast idle. The transmission shall be placed in gear 15 seconds after the engine is started. If necessary, braking may be employed to keep the drive wheels from turning.

(ii) Vehicles equipped with manual chokes shall be operated according to the manufacturer's operating instructions or owner's manual. Where times are provided in the instructions, the Administrator may specify the specific point for operation, within 15 seconds of the recommended time.

(3) The operator may use the choke, throttle etc. where necessary to keep the engine running.

(4) If the manufacturer's operating instructions or owner's manual do not specify a warm engine starting procedure, the engine (automatic and manual choke engines) shall be started by

opening the throttle about half way and cranking the engine until it starts.

(b) [Reserved]

(c) If, during the cold start, the vehicle does not start after 10 seconds of cranking, or ten cycles of the manual starting mechanism, cranking shall cease and the reason for failure to start determined. The revolution counter on the constant volume sampler shall be turned off and the sample solenoid valves placed in the "standby" position during this diagnostic period. In addition, either the CVS blower shall be turned off or the exhaust tube disconnected from the tailpipe during the diagnostic period.

(1) If failure to start is an operational error, the vehicle shall be rescheduled for testing from a cold start. If failure to start is caused by vehicle malfunction, corrective action (following the unscheduled maintenance provisions) of less than 30 minutes duration may be taken and the test continued. The sampling system shall be reactivated at the same time cranking is started. When the engine starts, the driving schedule timing sequence shall begin. If failure to start is caused by vehicle malfunction and the vehicle cannot be started, the test shall be voided, the vehicle removed from the dynamometer, corrective action taken (following the unscheduled maintenance provisions), and the vehicle rescheduled for test. The reason for the malfunction (if determined) and the corrective action taken shall be reported.

(2) If the vehicle does not start during the hot start after ten seconds of cranking, or ten cycles of the manual starting mechanism, cranking shall cease, the test shall be voided, the vehicle removed from the dynamometer, corrective action taken in accordance with § 86.428 or § 86.429, and the vehicle rescheduled for test. The reason for the malfunction (if determined) and the corrective action taken shall be reported.

(d) If the engine "false starts", the operator shall repeat the recommended starting procedure (such as resetting the choke, etc.)

(e) *Stalling.* (1) If the engine stalls during an idle period, the engine shall be restarted immediately and the test continued. If the engine cannot be

started soon enough to allow the vehicle to follow the next acceleration as prescribed, the driving schedule indicator shall be stopped. When the vehicle restarts, the driving schedule indicator shall be reactivated.

(2) If the engine stalls during some operating mode other than idle, the driving schedule indicator shall be stopped, the vehicle shall then be restarted and accelerated to the speed required at that point in the driving schedule and the test continued. During acceleration to this point, shifting shall be performed in accordance with § 86.528.

(3) If the vehicle will not restart within one minute, the test shall be voided, the vehicle removed from the dynamometer, corrective action taken, and the vehicle rescheduled for test. The reason for the malfunction (if determined) and the corrective action taken shall be reported.

§ 86.537-90 Dynamometer test runs.

(a) The vehicle shall be allowed to stand with the engine turned off (see § 86.532 for required time). The vehicle shall be stored prior to the emission test in such a manner that precipitation (e.g., rain or dew) does not occur on the vehicle. The complete dynamometer test consists of a cold start drive of 12.0 km (7.5 mi), (10.9 km (6.8 mi) for Class I motorcycles) and simulates a hot start drive of 12.0 km (7.5 mi), (10.9 km (6.8 mi) for Class I motorcycles). The vehicle is allowed to stand on the dynamometer during the 10-minute period between the cold and hot start tests. The cold start is divided into two periods. The first period, representing the cold start "transient" phase, terminates at the end of the deceleration which is scheduled to occur at 505 seconds of the driving schedule. The second period, representing the "stabilized" phase, consists of the remainder of the driving schedule including engine shutdown. The hot start test similarly consists of two periods. The period, representing the hot start "transient" phase, terminates at the same point in the driving schedule at the first point of the cold start test. The second period of the hot start test, "stabilized" phase, is assumed to be identical to the second period of the

cold start test. Therefore, the hot start test terminates after the first period (505 seconds) is run.

(b) The following steps shall be taken for each test:

(1) Place drive wheel of vehicle on dynamometer without starting engine.

(2) Activate vehicle cooling fan.

(3) For all vehicles, with the sample selector valves in the "standby" position connect evacuated sample collection bags to the dilute exhaust and dilution air sample collection systems.

(4) For methanol-fueled vehicles, with the sample selector valves in the "standby" position, insert fresh sample collection impingers into the methanol sample collection system, fresh impingers or a fresh cartridge into the formaldehyde sample collection system and fresh impingers (or a single cartridge for formaldehyde) into the dilution air sample collection systems for methanol and formaldehyde (background measurements of methanol and formaldehyde may be omitted and concentrations assumed to be zero for calculations in § 86.544).

(5) Start the CVS (if not already on), the sample pumps and the temperature recorder. (The heat exchanger of the constant volume sampler, if used, methanol-fueled vehicle hydrocarbon analyzer and sample lines should be preheated to their respective operating temperatures before the test begins.)

(6) Adjust the sample flow rates to the desired flow rate and set the gas flow measuring devices to zero.

(i) For gaseous bag samples (except hydrocarbon samples), the minimum flow rate is 0.17 cfm (0.08 l/s).

(ii) For hydrocarbon samples, the minimum FID (or HFID in the case of methanol-fueled vehicles) flow rate is 0.066 cfm (0.031 l/s).

(iii) For methanol samples, the flow rates shall be set such that the system meets the design criteria of § 86.509. For samples in which the concentration in the primary impinger exceeds 0.5 mg/l, it is recommended that the mass of methanol collected in the secondary impinger not exceed ten percent of the total mass collected. For samples in which the concentration in the primary impinger does not exceed 0.5 mg/l, secondary impingers do not need to be analyzed.

(iv) For formaldehyde samples, the flow rates shall be set such that the system meets the design criteria of § 86.509. For impinger samples in which the concentration of formaldehyde in the primary impinger exceeds 0.1 mg/l, it is recommended that the mass of formaldehyde collected in the secondary impinger not exceed ten percent of the total mass collected. For samples in which the concentration in the primary impinger does not exceed 0.1 mg/l, secondary impingers do not need to be analyzed.

(7) Attach the flexible exhaust tube to the vehicle tailpipe(s).

(8) Start the gas flow measuring device, position the sample selector valves to direct the sample flow into the "transient" exhaust sample bag, the "transient" methanol exhaust sample, the "transient" formaldehyde exhaust sample, the "transient" dilution air sample bag, the "transient" methanol dilution air sample and the "transient" formaldehyde dilution air sample, turn the key on, and start cranking the engine.

(9) Fifteen seconds after the engine starts, place the transmission in gear.

(10) Twenty seconds after the engine starts, begin the initial vehicle acceleration of the driving schedule.

(11) Operate the vehicle according to the Urban Dynamometer Driving Schedule (§ 86.515).

(12) At the end of the deceleration which is scheduled to occur at 505 seconds, simultaneously switch the sample flows from the "transient" bags and samples to "stabilized" bags and samples, switch off gas flow measuring device No. 1 and, start gas flow measuring device No. 2. Before the acceleration which is scheduled to occur at 510 seconds, record the measured roll or shaft revolutions and reset the counter or switch to a second counter. As soon as possible, transfer the "stabilized" exhaust and dilution air samples to the analytical system and process the samples according to § 86.540, obtaining a stabilized reading of the exhaust bag sample on all analyzers within 20 minutes of the end of the sample collection phase of the test. Obtain methanol and formaldehyde sample analyses, if applicable, within 24 hours of the end of the sample period. (If it is not possible to

perform analysis on the methanol and formaldehyde samples within 24 hours, the samples should be stored in a dark cold (4-10 °C) environment until analysis. The samples should be analyzed within fourteen days.)

(13) Turn the engine off 2 seconds after the end of the last deceleration (at 1,369 seconds).

(14) Five seconds after the engine stops running, simultaneously turn off gas flow measuring device No. 2 and position the sample selector valves to the "standby" position (and open the valves isolating particulate filter No. 1, if applicable). Record the measured roll or shaft revolutions (both gas meter or flow measurement instrumentation readings) and re-set the counter. As soon as possible, transfer the "stabilized" exhaust and dilution air samples to the analytical system and process the samples according to §86.540, obtaining a stabilized reading of the exhaust bag sample on all analyzers within 20 minutes of the end of the sample collection phase of the test. Obtain methanol and formaldehyde sample analyses, if applicable, within 24 hours of the end of the sample period. (If it is not possible to perform analysis on the methanol and formaldehyde samples within 24 hours, the samples should be stored in a dark cold (4-10 °C) environment until analysis. The samples should be analyzed within fourteen days.)

(15) Immediately after the end of the sample period, turn off the cooling fan.

(16) Turn off the CVS or disconnect the exhaust tube from the tailpipe(s) of the vehicle.

(17) Repeat the steps in paragraph (b) (2) through (11) of this section for the hot start test, except only two evacuated sample bags, two methanol sample impingers, and two formaldehyde sample impingers are required. The step in paragraph (b)(8) of this section shall begin between 9 and 11 minutes after the end of the sample period for the cold start test.

(18) At the end of the deceleration which is scheduled to occur at 505 seconds, simultaneously turn off gas flow measuring device No. 1 and position the sample selector valve to the "standby" position. (Engine shutdown is not part of the hot start test sample

period.) Record the measured roll or shaft revolutions.

(19) As soon as possible, transfer the hot start "transient" exhaust and dilution air bag samples to the analytical system and process the samples according to §86.540 obtaining a stabilized reading of the bag exhaust sample on all analyzers within 20 minutes of the end of the sample collection phase of the test. Obtain methanol and formaldehyde sample analyses, if applicable, within 24 hours of the end of the sample period (if it is not possible to perform analysis on the methanol and formaldehyde samples within 24 hours, the samples should be stored in a dark, cold (- 0 °C) environment until analysis).

(20) Disconnect the exhaust tube from the vehicle tailpipe(s) and remove the vehicle from dynamometer.

(21) The CVS or CFV may be turned off, if desired.

(22) Continuous monitoring of exhaust emissions will not normally be allowed. Specific written approval must be obtained from the Administrator for continuous monitoring of exhaust emissions.

[54 FR 14551, Apr. 11, 1989, as amended at 60 FR 34357, June 30, 1995]

§ 86.540-90 Exhaust sample analysis.

The following sequence of operations shall be performed in conjunction with each series of measurements:

(a) For CO, CO₂, gasoline-fueled, natural gas-fueled, liquefied petroleum gas-fueled and methanol-fueled motorcycle HC and, if appropriate, NO_x:

(1) Zero the analyzers and obtain a stable zero reading. Recheck after tests.

(2) Introduce span gases and set instrument gains. In order to avoid errors, span and calibrate at the same flow rates used to analyze the test sample. Span gases should have concentrations equal to 75 to 100 percent of full scale. If gain has shifted significantly on the analyzers, check the calibrations. Show actual concentrations on chart.

(3) Check zeros; repeat the procedure in paragraphs (a) (1) and (2) of this section if required.

(4) Check flow rates and pressures.

(5) Measure HC, CO, CO₂, and, if appropriate, NO_x, concentrations of samples.

(6) Check zero and span points. If difference is greater than 2 percent of full scale, repeat the procedure in paragraphs (a) (1) through (5) of this section.

(b) For CH₃OH (methanol-fueled vehicles), introduce test samples into the gas chromatograph and measure the concentration. This concentration is C_{MS} in the calculations.

(c) For HCHO (methanol-fueled vehicles), introduce test samples into the high pressure liquid chromatograph and measure the concentration of formaldehyde as a dinitrophenylhydrazine derivative in acetonitrile. This concentration is C_{FS} in the calculations.

[54 FR 14552, Apr. 11, 1989, as amended at 59 FR 48515, Sept. 21, 1994; 60 FR 34357, June 30, 1995]

§ 86.542-90 Records required.

The following information shall be recorded with respect to each test:

- (a) Test number.
- (b) System or device tested (brief description).
- (c) Date and time of day for each part of the test schedule.
- (d) Instrument operator.
- (e) Driver or operator.
- (f) *Vehicle*: Make, Vehicle identification number, Model year, Transmission type, Odometer reading at initiation of preconditioning, Engine displacement, Engine family, Emission control system, Recommended idle RPM, Nominal fuel tank capacity, Inertial loading, Actual curb mass recorded at 0 kilometers, and Drive wheel tire pressure.
- (g) *Dynamometer serial number*: As an alternative to recording the dynamometer serial number, a reference to a vehicle test cell number may be used, with the advance approval of the Administrator, provided the test cell records show the pertinent instrument information.
- (h) All pertinent instrument information such as tuning-gain-serial number-detector number-range. As an alternative, a reference to a vehicle test cell number may be used, with the advance approval of the Administrator, pro-

vided test cell calibration records show the pertinent instrument information.

(i) Recorder Charts: Identify zero, span, exhaust gas, and dilution air sample traces.

(j) Test cell barometric pressure, ambient temperature and humidity.

NOTE: A central laboratory barometer may be used; *Provided*, that individual test cell barometric pressures are shown to be within ± 0.1 percent of the barometric pressure at the central barometer location.

(k) [Reserved]

(l) Pressure of the mixture of exhaust and dilution air entering the CVS metering device, the pressure increase across the device, and the temperature at the inlet. The temperature may be recorded continuously or digitally to determine temperature variations.

(m) The number of revolutions of the positive displacement pump accumulated during each test phase while exhaust samples are being collected. The number of standard cubic meters metered by a critical flow venturi during each test phase would be the equivalent record for a CFV-CVS.

(n) The humidity of the dilution air.

NOTE: If conditioning columns are not used (see §§ 86.522 and 86.544) this measurement can be deleted. If the conditioning columns are used and the dilution air is taken from the test cell, the ambient humidity can be used for this measurement.

(o) The driving distance for each of the three phases of test, calculated from the measured roll or shaft revolutions.

(p) Additional required records for methanol-fueled vehicles:

(1) Specification of the methanol fuel, or fuel mixtures, used during testing.

(2) Volume of sample passed through the methanol sampling system and the volume of deionized water in each impinger.

(3) The methanol calibration information from the GC standards.

(4) The concentration of the GC analyses of the test samples (methanol).

(5) Volume of sample passed through the formaldehyde sampling system.

(6) The formaldehyde calibration information from the HPLC standards.

(7) The concentration of the HPLC analysis of the test sample (formaldehyde).

(q) *Additional required records for natural gas-fueled vehicles.* Composition, including all carbon containing compounds; e.g. CO₂, of the natural gas-fuel used during the test. C₁ and C₂ compounds shall be individually reported. C₃ and heavier hydrocarbons and C₆ and heavier compounds may be reported as a group.

(r) *Additional required records for liquefied petroleum gas-fueled vehicles.* Composition of the liquefied petroleum gas-fuel used during the test. Each hydrocarbon compound present, through C₄ compounds, shall be individually reported. C₅ and heavier hydrocarbons may be reported as a group.

[54 FR 14553, Apr. 11, 1989, as amended at 59 FR 48515, Sept. 21, 1994; 60 FR 34357, June 30, 1995]

§ 86.544-90 Calculations; exhaust emissions.

The final reported test results, with oxides of nitrogen being optional, shall be computed by use of the following formula: (The results of all emission tests shall be rounded, using the "Rounding-Off Method" specified in ASTM E 29-67, to the number of places to the right of the decimal point indicated by expressing the applicable standard to three significant figures.)

ER06OC93.109

Where:

(1) Y_{wm} = Weighted mass emissions of CO₂ or of each pollutant (*i.e.*, HC, CO, or NO_x) in grams per vehicle kilometer and if appropriate, the weighted carbon mass equivalent of total hydrocarbon equivalent, in grams per vehicle kilometer.

(2) Y_{ct} = Mass emissions as calculated from the "transient" phase of the cold-start test, in grams per test phase.

(3) Y_{ht} = Mass emissions as calculated from the "transient" phase of the hot-start test, in grams per test phase.

(4) Y_s = Mass emissions as calculated from the "stabilized" phase of the cold-start test, in grams per test phase.

(5) D_{ct} = The measured driving distance from the "transient" phase of the cold-start test, in kilometers.

(6) D_{ht} = The measured driving distance from the "transient" phase of the hot-start test, in kilometers.

(7) D_s = The measured driving distance from the "stabilized" phase of the cold-start test, in kilometers.

(b) The mass of each pollutant for each phase of both the cold-start test and the hot-start test is determined from the following:

(1) Hydrocarbon mass:

$$HC_{\text{mass}} = V_{\text{mix}} \times \text{Density}_{\text{HC}} \times (HC_{\text{conc}} / 1,000,000)$$

(2) Oxides of nitrogen mass:

$$NOx_{\text{mass}} = V_{\text{mix}} \times \text{Density}_{\text{NO}_2} \times K_H \times (NOx_{\text{conc}} / 1,000,000)$$

(3) Carbon monoxide mass:

$$CO_{\text{mass}} = V_{\text{mix}} \times \text{Density}_{\text{CO}} \times (CO_{\text{conc}} / 1,000,000)$$

(4) Carbon dioxide mass:

$$CO_{2\text{mass}} = V_{\text{mix}} \times \text{Density}_{\text{CO}_2} \times (CO_{2\text{conc}} / 100)$$

(5) Methanol mass:

$$CH_3OH_{\text{mass}} = V_{\text{mix}} \times \text{Density}_{\text{CH}_3\text{OH}} \times (CH_3OH_{\text{conc}} / 1,000,000)$$

(6) Formaldehyde mass:

$$HCHO_{\text{mass}} = V_{\text{mix}} \times \text{Density}_{\text{HCHO}} \times (HCHO_{\text{conc}} / 1,000,000)$$

(7) Total hydrocarbon equivalent:

$$(i) \text{ THCE} = HC_{\text{mass}} + 13.8756/32.042 \times (CH_3OH)_{\text{mass}} + 13.8756/30.0262 \times (HCHO)_{\text{mass}}$$

(c) Meaning of symbols:

(1) (i) HC_{mass} = Hydrocarbon emissions, in grams per test phase.

(ii) Density_{HC} = Density of HC in exhaust gas.

(A) *For gasoline-fuel*; Density_{HC} = 576.8 g/m³-carbon atom (16.33 g/ft³-carbon atom), assuming an average carbon to hydrogen ratio of 1:1.85, at 20 °C (68 °F) and 101.3 kPa (760 mm Hg) pressure.

(B) *For natural gas and liquefied petroleum gas-fuel*; Density_{HC} = 41.57(12.011+H/C(1.008)) g/m³-carbon atom (1.1771(12.011+H/C(1.008)) g/ft³-carbon atom) where H/C is the hydrogen to carbon ratio of the hydrocarbon components of test fuel, at 20 °C (68 °F) and 101.3 kPa (760mm Hg) pressure.

(iii) (A) HC_{conc} = Hydrocarbon concentration of the dilute exhaust sample corrected for background, in ppm carbon equivalent, *i.e.*, equivalent propane x 3.

(B) HC_{conc} = HC_e - HC_d(1 - (1/DF))

Where:

(iv) (A) HC_e = Hydrocarbon concentrations of the dilute exhaust sample as

measured, in ppm carbon equivalent (propane ppm x 3).

(B) $HC_e = FIDHC_e - (r)C_{CH_3OH_e}$

(v) FID HC_e = Concentration of hydrocarbon (plus methanol if methanol-fueled motorcycle is tested) in dilute exhaust as measured by the FID ppm carbon equivalent.

(vi) r = FID response to methanol.

(vii) $C_{CH_3OH_e}$ = Concentration of methanol in dilute exhaust as determined from the dilute exhaust methanol sample, ppm carbon.

(viii)(A) HC_d = Hydrocarbon concentration of the dilution air as measured, ppm carbon equivalent.

(B) $HC_d = FID HC_d - (r)C_{CH_3OH_d}$

(ix) FID HC_d = Concentration of hydrocarbon (plus methanol if methanol-fueled motorcycle is tested) in dilution air as measured by the FID, ppm carbon equivalent.

(x) $C_{CH_3OH_d}$ = Concentration of methanol in dilution air as determined from dilution air methanol sample, ppm carbon.

(2)(i) $NO_{x_{mass}}$ = Oxides of nitrogen emissions, grams per test phase.

(ii) $Density_{N_{O_2}}$ = Density of oxides of nitrogen in the exhaust gas, assuming they are in the form of nitrogen dioxide, 1913 g/m³ (54.16 g/ft³), at 20 °C (68 °F) and 101.3 kPa (760 mm Hg) pressure.

(iii)(A) $NO_{x_{conc}}$ = Oxides of nitrogen concentration of the dilute exhaust sample corrected for background, ppm.

(B) $NO_{x_{conc}} = NO_{x_e} - NO_{x_d}(1 - (1/DF))$

Where:

(iv) NO_{x_e} = Oxides of nitrogen concentration of the dilute exhaust sample as measured, ppm.

(v) NO_{x_d} = Oxides of nitrogen concentration of the dilution air as measured, ppm.

(3)(i) CO_{mass} = Carbon monoxide emissions, in grams per test phase.

(ii) $Density_{CO}$ = Density of carbon monoxide, 1164 g/m³ (32.97 g/ft³), at 20 °C (68 °F) and 101.3 kPa (760 mm Hg) pressure.

(iii)(A) CO_{conc} = Carbon monoxide concentration of the dilute exhaust sample corrected for background, water vapor, and CO₂ extraction, ppm.

(B) $CO_{conc} = CO_e - CO_d(1 - (1/DF))$

Where:

(iv)(A) CO_e = Carbon monoxide concentration of the dilute exhaust sample

volume corrected for water vapor and carbon dioxide extraction, in ppm.

(B) $CO_e = (1 - 0.01925CO_{2e} - 0.000323R)CO_{em}$ for gasoline-fueled vehicles with hydrogen to carbon ratio of 1.85:1

(C) $CO_e = [1 - (0.01 + 0.005HCR) CO_{2e} - 0.000323R]CO_{em}$ for methanol-fueled, natural gas-fueled or liquefied petroleum gas-fueled motorcycles, where HCR is hydrogen to carbon ratio as measured for the fuel used.

(v) CO_{em} = Carbon monoxide concentration of the dilute exhaust sample as measured, ppm

(vi) CO_{2e} = Carbon dioxide concentration of the dilute exhaust sample, pct.

(vii) R = Relative humidity of the dilution air, pct (see § 86.542(n)).

(viii)(A) CO_d = Carbon monoxide concentration of the dilution air corrected for water vapor extraction, ppm.

(B) $CO_d = (1 - 0.000323R)CO_{dm}$

Where:

(ix) CO_{dm} = Carbon monoxide concentration of the dilution air sample as measured, ppm.

NOTE: If a CO instrument which meets the criteria specified in § 86.511 is used and the conditioning column has been deleted, CO_{em} can be substituted directly for CO_e and CO_{dm} must be substituted directly for CO_d .

(4)(i) $CO_{2_{mass}}$ = Carbon dioxide emissions, grams per test phase.

(ii) $Density_{CO_2}$ = Density of carbon dioxide, 1830 g/m³ (51.81 g/ft³), at 20 °C (68 °F) and 101.3 kPa (760 mm Hg) pressure.

(iii)(A) $CO_{2_{conc}}$ = carbon dioxide concentration of the dilute exhaust sample corrected for background, in percent.

(B) $CO_{2_{conc}} = CO_{2e} - CO_{2d}(1 - 1/DF)$

Where:

(iv) CO_{2d} = Carbon dioxide concentration of the dilution air as measured, in percent.

(5)(i) CH_3OH_{mass} = Methanol emissions corrected for background, grams per test phase.

(ii) $Density_{CH_3OH}$ = Density of methanol is 1332 g/m³ (37.71 g/ft³), at 20 °C (68 °F) and 101.3 kPa (760 mm Hg) pressure.

(iii)(A) CH_3OH_{conc} = Methanol concentration of the dilute exhaust corrected for background, ppm.

(B) $CH_3OH_{conc} = C_{CH_3OH_e} - C_{CH_3OH_d}(1 - (1/DF))$

Where:

(iv)(A) $C_{CH_3OH_e}$ = Methanol concentration in the dilute exhaust, ppm.

(B)

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(v)(A) $C_{\text{CH}_3\text{OHd}}$ =Methanol concentration in the dilution air, ppm. (B)

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(vi) T_{EM} =Temperature of methanol sample withdrawn from dilute exhaust, °R.

(vii) T_{DM} =Temperature of methanol sample withdrawn from dilution air, °R.

(viii) P_{B} =Barometric pressure during test, mm Hg.

(ix) V_{EM} =Volume of methanol sample withdrawn from dilute exhaust, ft³.

(x) V_{DM} =Volume of methanol sample withdrawn from dilution air, ft³.

(xi) C_{S} =GC concentration of sample drawn from dilute exhaust, µg/ml.

(xii) C_{D} =GC concentration of sample drawn from dilution air, µg/ml.

(xiii) AV_{S} =Volume of absorbing reagent (deionized water) in impinger through which methanol sample from dilute exhaust is drawn, ml.

(xiv) AV_{D} =Volume of absorbing reagent (deionized water) in impinger

through which methanol sample from dilution air is drawn, ml.

(xv) 1=first impinger.

(xvi) 2=second impinger.

(6)(i) $\text{HCHO}_{\text{mass}}$ = Formaldehyde emissions corrected for background, grams per test phase.

(ii) $\text{Density}_{\text{HCHO}}$ = Density of formaldehyde is 1249 g/m³ (35.36 g/ft³), at 20 °C (68 °F) and 101.3 kPa (760 mm Hg) pressure.

(iii)(A) $\text{HCHO}_{\text{conc}}$ = Formaldehyde concentration of the dilute exhaust corrected for background, ppm.

(B) $\text{HCHO}_{\text{conc}} = C_{\text{HCHOe}} - C_{\text{HCHOd}} (1 - (1/\text{DF}))$

Where:

(iv)(A) C_{HCHOe} = Formaldehyde concentration in dilute exhaust, ppm.

(B)

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(v)(A) C_{HCHOd} = Formaldehyde concentration in dilution air, ppm. (B)

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(vi) C_{FDE} = Concentration of DNPH derivative of formaldehyde from dilute exhaust sample in sampling solution, $\mu\text{g}/\text{ml}$.

(vii) V_{AE} = Volume of sampling solution for dilute exhaust formaldehyde sample, ml.

(viii)(A) Q = Ratio of molecular weights of formaldehyde to its DNPH derivative.

(B) $Q = 0.1429$

(ix) T_{EF} = Temperature of formaldehyde sample withdrawn from dilute exhaust, $^{\circ}\text{R}$.

(x) V_{SE} = Volume of formaldehyde sample withdrawn from dilute exhaust, ft^3 .

(xi) P_B = Barometric pressure during test, mm Hg.

(xii) C_{FDA} = Concentration of DNPH derivative of formaldehyde from dilu-

tion air sample in sampling solution, $\mu\text{g}/\text{ml}$.

(xiii) V_{AA} = Volume of sampling solution for dilution air formaldehyde sample, ml.

(xiv) T_{DF} = Temperature of formaldehyde sample withdrawn from dilution air, $^{\circ}\text{R}$.

(xv) V_{SA} = Volume of formaldehyde sample withdrawn from dilution air, ft^3 .

(7)(i) $DF = 13.4/[\text{CO}_{2e} + (\text{HC}_e + \text{CO}_e)10^{-4}]$ for gasoline-fueled vehicles.

(ii) For methanol-fueled, natural gas-fueled or liquefied petroleum gas-fueled motorcycles, where fuel composition is $\text{C}_x \text{H}_y \text{O}_z$ as measured, or calculated, for the fuel used (for natural gas and liquefied petroleum gas-fuel, $Z=0$):

ER30JN95.024

(iii)(A) V_{mix} = Total dilute exhaust volume in cubic meters per test phase corrected to standard conditions (293 $^{\circ}\text{K}$ (528 $^{\circ}\text{R}$) and 101.3 kPa (760 mm Hg)).

(B)

ER06OC93.235

Where:

(iv) V_o = Volume of gas pumped by the positive displacement pump, in cubic meters per revolution. This volume is dependent on the pressure differential across the positive displacement pump. (See calibration techniques in § 86.519.)

(v) N = Number of revolutions of the positive displacement pump during the test phase while samples are being collected.

(vi) P_B = Barometric pressure, kPa.

(vii) P_i = Pressure depression below atmospheric measured at the inlet to the positive displacement pump, kPa.

(viii) T_p = Average temperature of dilute exhaust entering positive displace-

ment pump during test while samples are being collected, $^{\circ}\text{K}$.

(ix)(A) K_h = Humidity correction factor.

(B) $K_h = 1/[1 - 0.0329(H - 10.71)]$

Where:

(x)(A) H = Absolute humidity in grams of water per kilogram of dry air.

(B) $H = [(6.211)R_a \times P_d]/[P_B - (P_d \times R_a/100)]$

(xi) R_a = Relative humidity of the ambient air, pct.

(xii) P_d = Saturated vapor pressure, in kPa at the ambient dry bulb temperature.

(xiii) P_B = Barometric pressure, kPa.

(d) Sample calculation of mass emission values for gasoline-fueled vehicles with engine displacements equal to or greater than 170 cc (10.4 cu. in.):

(1) For the "transient" phase of the cold-start test, assume $V_o = 0.0077934 \text{ m}^3$ per rev; $N = 12,115$; $R = 20.5$ pct; $R_a = 20.5$ pct; $P_B = 99.05$ kPa; $P_d = 3.382$ kPa; $P_i = 9.851$ kPa; $T_p = 309.8$ $^{\circ}\text{K}$; $\text{HC}_e = 249.75$ ppm carbon equivalent; $\text{NOx}_e = 38.30$ ppm; $\text{CO}_{em} = 311.23$ ppm; $\text{CO}_{2e} = 0.415$ percent; $\text{HC}_d = 4.90$ ppm; $\text{NOx}_d =$

0.30 ppm; $\text{CO}_{\text{dm}} = 8.13$ ppm; $\text{CO}_{2\text{d}} = 0.037$ pct; $D_{\text{ct}} = 5.650$ km.

Then:

(i) $V_{\text{mix}} = [(0.0077934)(12,115)(99.05 - 9.851)(293.15)] / [(101.325)(309.8)] = 78.651$ m³ per test phase.

(ii) $H = [(6.211)(20.5)(3.382)] / [(99.05) - (3.382)(20.5/100)] = 4.378$ grams H₂O per kg dry air.

(iii) $K_h = 1/[1 - 0.0329(4.378 - 10.71)] = 0.8276$

(iv) $\text{CO}_e = [1 - 0.01925(0.415) - 0.000323(20.5)](311.23) = 306.68$ ppm.

(v) $\text{CO}_d = [1 - 0.000323(20.5)](8.13) = 8.08$ ppm.

(vi) $DF = 13.4/[0.415 + (249.75 + 306.68)10^{-4}] = 28.472$

(vii) $\text{HC}_{\text{conc}} = 249.75 - 4.90(1 - 1/28.472) = 245.02$ ppm.

(viii) $\text{HC}_{\text{mass}} = (78.651)(576.8)(245.02)10^{-6} = 11.114$ grams per test phase.

(ix) $\text{NOx}_{\text{conc}} = 38.30 - 0.30(1 - 1/28.472) = 38.01$ ppm.

(x) $\text{NOx}_{\text{mass}} = (78.651)(1913)(38.01)(0.8276) \times 10^{-6} = 4.733$ grams per test phase.

(xi) $\text{CO}_{\text{conc}} = 306.68 - 8.08(1 - 1/28.472) = 298.88$ ppm.

(xii) $\text{CO}_{\text{mass}} = (78.651)(1164)(298.88)10^{-6} = 27.362$ grams per test phase.

(xiii) $\text{CO}_{2\text{conc}} = 0.415 - 0.037(1 - 1/28.472) = 0.3793$ percent.

(xiv) $\text{CO}_{2\text{mass}} = (78.651)(1843)(0.3793)/100 = 549.81$ grams per test phase.

(2) For the "stabilized" portion of the cold-start test, assume that similar

calculations resulted in $\text{HC}_{\text{mass}} = 7.184$ grams per test phase; $\text{NOx}_{\text{mass}} = 2.154$ grams per test phase; $\text{CO}_{\text{mass}} = 64.541$ grams per test phase; and $\text{CO}_{2\text{mass}} = 529.52$ grams per test phase. $D_s = 6.070$ km.

(3) For the "transient" portion of the hot-start test, assume that similar calculations resulted in $\text{HC}_{\text{mass}} = 6.122$ grams per test phase; $\text{NOx}_{\text{mass}} = 7.056$ grams per test phase; $\text{CO}_{\text{mass}} = 34.964$ grams per test phase; and $\text{CO}_{2\text{mass}} = 480.93$ grams per test phase. $D_{\text{ht}} = 5.660$ km.

(4) For a 1978 motorcycle with an engine displacement equal to or greater than 170 cc (10.4 cu. in):

(i) $\text{HC}_{\text{wm}} = 0.43 [(11.114 + 7.184)/(5.650 + 6.070)] + 0.57 [(6.122 + 7.184)/(5.660 + 6.070)] = 1.318$ grams per vehicle kilometer.

(ii) $\text{NOx}_{\text{wm}} = 0.43 [(4.733 + 2.154)/(5.650 + 6.070)] + 0.57 [(7.056 + 2.154)/(5.660 + 6.070)] = 0.700$ gram per vehicle kilometer.

(iii) $\text{CO}_{\text{wm}} = 0.43 [(27.362 + 64.541)/(5.650 + 6.070)] + 0.57 [(34.964 + 64.541)/(5.660 + 6.070)] = 8.207$ grams per vehicle kilometer.

(iv) $\text{CO}_{2\text{wm}} = 0.43 [(549.81 + 529.52)/(5.650 + 6.070)] + 0.57 [(480.93 + 529.52)/(5.660 + 6.070)] = 88.701$ grams per vehicle kilometer.

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